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ART. XXVII.—*Review of DeCandolle's Origin of Cultivated Plants;* with Annotations upon certain American Species;* by ASA GRAY and J. HAMMOND TRUMBULL.

M. ALPHONSE DE CANDOLLE'S *Géographie Botanique Raisonnée*, in two volumes of nearly 700 pages each, was published in the year 1855, and has been for several years out of print. It is not surprising that the now venerable but still well-busied author should decline the labor of preparing a new edition, involving, as it would, the re-discussion of certain questions under changed points of view, and the collocation of a vast amount of widely scattered new materials which the last quarter of a century has brought to us.

Happily, the chapter on the geographical origin of the species of plants generally cultivated for food, and for other economical uses, could be detached. This, the author has sedulously studied anew; and the present volume is the result. As yet we have it only in the original French; but it is said that an English translation is in preparation. So, if the work is not already in the hands of botanists and other scholars generally, we may expect that it soon will be; and, contenting ourselves with a mere mention of its plan and scope, we may proceed to

* *Origine des Plantes Cultivées*, par ALPH. DE CANDOLLE, Associé Etranger de l'Academie des Sciences de l'Institut de France, etc. Paris, 1883, pp. 377, 8vo. (Bibl. Scientifique Internationale, XLIII.) Baillière et Cie.

remark, here and there, upon points which strike our attention.* We may expect this to be for many years the standard work upon the subject, and to undergo revision in successive editions; and we are sure that the excellent author will welcome every presentation or discussion which may chance to throw any new light upon the sources or the aboriginal cultivation of certain plants which the Old World has drawn from the New.

The first part of the volume, of only 22 pages, is mainly occupied with a consideration of the means employed for the determination of the sources whence the various cultivated plants have been derived. The botanist enquires where a given cultivated plant grows spontaneously, or what was its wild original; and he has to judge, as well as he can, where it is truly indigenous or where a reversion from a cultivated to a wild condition. This, as respects weeds and the like, is a difficult matter, even in a newly settled country like North America, much more so in the Old World; but as respects the plants of agriculture, the case is usually simpler. The botanists resident in a country are not likely to be far misled by the occurrence of *wilderings;* but, in the case of travelers and collectors, perhaps too much has been made, even in this volume, of plants only once met with growing spontaneously, and inferred to be indigenous. Plentifulness is of no account, else the Century plant and Opuntia would be thought indigenous to the Mediterranean region; the Ox-eye Daisy to the United States, and certainly the Cardoon to the Pampas, where there is now probably more of it than anywhere in the Old World. Archæology and palæontology are often helpful, as by the identification of fruits and seeds in ancient Egyptian tombs, or of paintings upon their walls, or of fragments in ancient bricks; or the *débris* of lake-dwellings rescued from lacustrine deposits, as in Switzerland; and from the tufas of Southern France, the kiökenmöddings of Scandinavia, the mounds of North America, and

* To avoid repetition, it may be mentioned here that, in the following annotations, the Relations of the Voyages of Columbus are cited from Navarrete's *Coleccion de los Viajes*, etc. (Madrid, 1858, and 1827-37); references to PETER MARTYR D'ANGHIERA'S first three Decades *De Rebus Oceanicis et Novo Orbe*—written before 1517—are to the Cologne edition of 1574; references to OVIEDO'S *Historia General y Natural de las Indias*—of which the first nineteen books, published in 1535, included a revised and enlarged edition of his [Relacio sumaria] *de la Nat. Historia de las Indias*, printed in 1526—are to the edition published by the Royal Academy of History, of Madrid, 1851–55; JEAN DE LERY'S *Histoire d'un Voyage faict en la terre du Brasil* (in 1557–8) is referred to in his revised edition in Latin, *Historia Navigationis in Brasiliam* (Genevæ, 1586); FR. HERNANDEZ, *Nova Plantarum*, etc., *Historia*, in the edition of Rome, 1651; *Rariorum Stirpium Historia* by L'ECLUSE (Clusius), in the first edition, Antwerp, 1576; his *Exotica*, including his translations of Monardes and Acosta, Antwerp, 1605, with his *Curæ Posteriores* (posthumous), 1611. J. H. T.

Il va sans dire—yet should explicitly be said—that all the historical and philological lore, which gives this article its value, is contributed by my associate.

A. G.

the ancient monuments and tombs of Mexico and Peru. Historical documents are also important for the date of certain cultures in particular countries; and here it is stated that the principal cultures have come from three great regions, viz: China, Southeastern Asia and Egypt, and intertropical America. DeCandolle also remarks that in the Old World agriculture was developed along rivers, in the New, upon plateaux, —a fact which he attributes to the primitive situation of certain plants worth cultivating. But this is not quite obvious. Linguistic learning may be turned to much account; as in tracing a plant towards its home by the name which has gone forth with it in all its migrations. Like other instruments this must be used with some knowledge and judgment. *Blé de Turquie* (maize) did not come from, and probably not by way of, Turkey, any more than did the animal of that name. *Jerusalem Artichoke* has nought to do with Jerusalem, but came from North America, and is no artichoke. *Pomme d'Acajou*, anglice, Mahogany-apple, is neither an apple nor a pomaceous plant, nor has it anything to do with mahogany. New Zealand Flax came indeed from New Zealand, but is not a Flax. Among errors from the careless transference of names from one plant to another, that of Potato, which belongs to the *Batatas* or Sweet Potato, is familiar. Of mistakes which have been made in the transference of a popular name from one language to another, DeCandolle mentions the *Arbre de Judée* of the French, which in English has become Judas-tree. We may add that of *Bois fidèle*, of the French West Indians, which, taken up by their English successors as Fiddle-wood, has been perpetuated in the generic name *Citharexylum*.

The several lines of evidence,—botanical, archæological, palæontological, historical, and linguistic—may be used to supplement or correct each other. How they may be brought to bear, and how their combination may give satisfactory results, is practically shown in Part II,—a study of the species as regards their origin, their earliest culture, and the principal facts of their dispersion,—which makes up the principal bulk of the volume, viz: from p. 23 to p. 350.

This part is divided into Chapters, e. g. Plants cultivated for their subterranean parts, such as roots, bulbs, tubers, etc. Those cultivated for their herbage, whether for human food, for forage, for fibers, for stimulation, etc.; but the proper medical plants are left wholly out of view, as likewise plants cultivated for ornament. So the chapter on plants cultivated for their blossoms, or parts connected with these, is brief enough,—treating as it does only of the Clove, Hop, Safflower and Saffron. For the Rose, Acacia Farnesiana, and all plants however largely cultivated for perfume or for essential oils are

left out of view. So also are the sweet-herbs of the kitchen garden, and all condiments, except Horse-radish. Plants cultivated for their fruits and seeds occupy the closing chapters. Among the latter the Cotton-plant is placed. The arrangement matters little, and that adopted may be the most convenient. A good index makes ready reference to any topic.

In the order of the book we come first to *Helianthus tuberosus*, the *Topinambour* of the French, Jerusalem Artichoke of the English; in the United States the tubers simply called artichokes. Almost all we know of the origin and source of these esculent tubers has been recovered since the publication of DeCandolle's earlier work, in 1855. Although the contemporary accounts specified its introduction from Canada, and Linnæus so cites it in the Hortus Cliffortianus, the subsequent reference to Brazil was followed without question down to DeCandolle's Prodromus; and the present author, in the work above mentioned, doubted the Canadian as well as the Brazilian origin. It now appears that Schlechtendal (in Bot. Zeitung, 1858) was the first to recover a part of the documentary history. Our own article on the subject—to which there is nothing of importance to add—was contributed to this Journal for May, 1877.* Singularly, it has remained unknown to DeCandolle, although it is referred to at the close of Decaisne's independent and exhaustive article, in the Flore des Serres, 1881.

It can now be said that the wild plant to which *Helianthus tuberosus* has been traced is not *H. doronicoides* Lam., although it was confounded with that species in Torrey and Gray's Flora. Lamarck's plant is a sessile-leaved species. Decaisne's remark that *H. tuberosus* is the only species of the genus which is at all tuberiferous may be qualified. A form of what appears to

* In it reference was made to Lescarbot's mention of roots "grosses comme naveaux . . . ayans un goût retirant aux cardes," etc., and cited his *Histoire de la Nouv. France*, in the edition of 1612 (p. 840). In a subsequent edition (1618), cited by M. DeCandolle, Lescarbot adds that he had brought these roots into France, where they began to be sold under the name of *Topinambaux*, and that their Indian name was *Chiquebi*. On this last point, Lescarbot was wrong. *Chiquebi* was an eastern Algonkin name for the tubers of *Apios tuberosa*, the common "ground nuts."—not for those of *Helianthus tuberosus*. It is easy to see how Lescarbot was misled. Father Biard's *Relation de la Nouv. France* was printed in 1616, and in it (chap. 22) there is mention of certain "racines, appellées en Sauvage *Chiquebi*," which grow spontaneously under oaks: "elles sont comme des truffes, mais meilleures, et croissent sous terre *enfilées l'une à l'autre en forme de chapelet*," etc. Lescarbot doubtless caught the name from Biard, and misapplied it. Father Paul Le Jeune (*Relation*, 1634, chap. 7) mentions these ground-nuts, "une racine que nos François appellent des *chapelets*, pource qu'elle est distinguée par nœuds en forme de grains." Lescarbot's "Topinambaux" indicates a popular belief, in France, in the Brazilian origin of H. tuberosus. The Tupinamba Indians of Brazil—a division of the Tupi-Guarani family—had been allies of the French in the 16th century, and their name was probably well known in France through the relations of J. de Lery and other voyagers. Lescarbot (*Hist. de la N. F.*, 1612, p. 178) follows Lery in writing the name *Tououpinambaoult*. J. H. T.

be *H. giganteus*, but is not yet very well known, grows in Minnesota and the Saskatchewan region, has been mentioned by Douglas under the name of Indian potato of the Assiniboine tribe, by Bourgeau as "*H. subtuberosus*," in herb. Kew, and by Dr. C. C. Parry in Owen's Minnesota Report, p. 614, under the name of *H. tuberosus*. The scanty tubers which we have seen in dried specimens do not compare well with those of *H. tuberosus;* and that species has never been found wild so far north (that we know of), not even in the most southern parts of Canada West. The aborigines who cultivated it must have obtained it from the valleys of the Ohio and Mississippi and their tributaries, where it abounds.

Helianthus annuus L.,—the history of which was almost equally confused, and which we had identified with a widespread species of the Western United States—is omitted by DeCandolle, yet might claim a place: for Decaisne, who has treated it at length in the paper above cited, informs us that a form of it (called Russian Sunflower) is cultivated in Russia, for the oil of its large seeds, and, if we mistake not, for fattening poultry. Our Indians also cultivated it for the oil of the seeds, which they used for greasing their hair, also for eating and other purposes. Champlain noted this (in 1610?), and Sagard about a dozen years later.* The latter says (*Histoire du Canada*, 1636, p. 785): "Ils font estat du tourne-sol, qu'ils sement en quantité, en plusieurs endroits à cause de l'huyle qu'ils tirent de la graine," etc., piously adding: "Mais comment est-ce que ce peuple sauvage a pû trouver l'invention de tirer d'une huyle que nous ignorons, sinon à l'ayde de la divine Providence." The wild original of this Sunflower must have

* Champlain's earlier record of the cultivation and use of the Sunflower is essentially like that of Sagard, and both relate to the same stations, namely, the Huron towns near the southeastern point of Georgian Bay. This Champlain reached by way of the Ottawa (R. des Prairies) and Lake Nipissing. The lamented Decaisne has here introduced some confusion into the history, which we hasten to rectify. In his article in the *Flore des Serres* (xxiii, p. 108, p. 2 of the pamphlet), he says, "Je trouve dans Champlain l'observation suivante (*Voyag. Nouv. France*, réimpress. 1830, tom. i, p. 110):"

"En remontant le St. Laurent et avant l'arriver au Lac Ontario, je visitai cinq des principaux villages fermés de palisades de bois, jusqu' à Cahiagué," etc., and so on to the mention of the "grande quantité de bled l'Inde (Maïs) qui y vient très beau, comme aussi des citrouilles. Herbe des soleil, dont ils font de l'huile, de la graine de laquelle ils se frottent la tête."

This, the latitude of 44.50° being stated, would refer Cahiagué and the Sunflower cultivation to the neighborhood of Ogdensburgh and Prescott, far away from the actual place (the Indian town mentioned being the Huron name of the mission station of San Jean Baptiste, in what is now Simcoe Co.), and it introduces a palpable anachronism, "Ontario" having been an unknown name in Champlain's time. In fact, there is nothing answering to the early part of this pretended quotation, either in the original of Champlain or in the edition here cited by name and page. The excellent Decaisne could never have tampered with the quotation himself. He must have taken it at second hand and neglected to verify it.

been obtained by the Canadian Indians from beyond the Mississippi, and some degrees farther south. Judging from the breadth of the flower-heads soon after its introduction into Europe, it must in aboriginal hands have assumed much of the abnormal development which distinguishes the cultivated Sunflower from its wild original of the western plains.

Solanum tuberosum L.—The question of the Potato was fully discussed by DeCandolle in 1855; and the present review of it only confirms the now generally admitted conclusions. These are summed up in the statements, that the plant is spontaneous in Chili under a form quite identical with the cultivated species, that its aboriginal cultivation had extended as far north as New Grenada, but apparently no farther; that allied tuberiferous species, which our author regards as distinct (though others partly doubt it) are found along the Andes and through Mexico, and within the borders of the United States; that when known in Virginia and North Carolina in the second half of the 16th century, it was not derived from our Indians; and that it was carried to Europe first by the Spaniards between 1580 and 1585, and afterwards by the English.

Batatas vulgaris Choisy, *Convolvulus Batatas* L., the *Sweet Potato*, is one of a few cultivated plants which have attained to a very wide distribution over the warmer parts of the world in early times; and it is one which no botanist pretends to have seen in a truly wild state. The evidence inclines to an American origin; but it had reached the Pacific islands in prehistoric times, and was cultivated in China in the second or third century of our era. DeCandolle states that:—

"Clusius, one of the first to speak of the Batatas, says that he had eaten it in the south of Spain, where it was said to have come from the New World. He indicates the names of *Batatas*, *Amotes*, *Ajes*."

The testimony of Clusius (L'Ecluse) to the American origin of the Sweet Potato, though not of the highest value, might be more strongly stated. He visited Spain and Portugal in 1566. The first edition of his *Historia Rariorum Stirpium* was printed in 1576, and contains the description of *Batatas*, which M. DeCandolle cites from the edition of 1601. He gives a figure of the plant, of which, he says he had observed three varieties growing in the south of Spain. He states their American origin, not as a doubtful matter or with a "l'on pretendait," but as a well established fact: "Spontè nascitur in novo orbe, vicinisque insulis, unde primum in Hispaniam delata est." "Now," he adds, "it is planted in many places near coast of Andalusia; but those grown at Malaga are preferred, and are transported to Cadiz and Seville. We sometimes have them fresh in Belgium, but they will not germinate here, the

country being too cold." As to the *name*—he was as undecided as have been some botanists since his time: "the Spaniards call them *Batatas*, and also *Camotes* or *Amotes;* some also *Ajes;* yet, as they say, they differ among themselves, and the root of *Batatas* may be much the sweeter and the more tender."

This confusion of names dates from the time of Columbus—for Clusius was not, by half a century, the first to speak of the *Batata.* (It may be worth noting, in parenthesis, that *Batatas*, the specific name adopted by Linnæus, and as the name of a genus by Choisy, is the Spanish *plural* of Batata, the aboriginal name.) Even Peter Martyr and Oviedo do not agree, in all particulars, as to the distinction between *Ajes* and *Batatas*—a distinction which both recognize. In the 9th book of his second Decade, written about 1514, Peter Martyr (ed. 1574, p. 191) describing the fruits, etc., of the province of Uraba, Darien, names, for the first time, *Batatæ:* "They dig from the earth," he says, "roots that *grow spontaneously* (*suapte natura nascentes*), the natives call them *Batatas* [accus. plural], which when I saw I thought to be rapes of Lombardy [? 'Insubres napos'] or great earth-tubers [*Cyclamen Europæum? Rapum terræ* and *Tuber terræ* of the old botanists]. In whatever way they are cooked, roasted or boiled, they yield in delicate sweetness,* to no confectionery or other eatable whatsoever." They are, he adds, "*also* planted and cultivated in gardens." In his 3d Decade (lib. 4, p. 240) he mentions "maize, yucca, *ages* and *battatæ*," as plants that grew in Honduras when Columbus landed on that coast in 1502; and in the same Decade (lib. 5, p. 261), he names the same four plants as the ordinary food of the people of Caramaira (east of Darien) "as of the others," and again takes occasion to name the battatas, as surpassing all else "mirâ quâdam dulci mollitie—especially if one falls on the better sort (nobiliores) of them."

Oviedo gives a good description of the *Batata*, which, when he wrote (1525–35), was commonly cultivated by the Indians in Hispaniola and elsewhere, and highly prized (*Hist. gen.*, lib. vii, c. 4). It resembles the *Ajes*, he says, in appearance, but tastes better and is far more delicate. The leaf is more notched (*harpada*) than that of the *Age*, in nearly the same fashion. Some varieties are better than others, and he gives the names of the five kinds which are most highly esteemed. [Peter Martyr (dec. iii, lib. 9, p. 302) included the same five names among the nine varieties of *Ajes* that he mentioned as distinct; but in this, as in other matters pertaining to natural history, Oviedo is the better authority.] "When the *Batatas* are well cured,

* The sweet potato was an inspiration to Peter Martyr, who rarely indulged himself in such a flight as "dulcorata mollities."

they have often been carried to Spain, when the ships happened to make a quick passage, but more often they are lost on the voyage. Yet," adds Oviedo, "*I have carried them* from this city of Saint Domingo in Hispaniola, *to the city of Avila*," in Old Castile.

The "Gentleman of Elvas" who wrote the "True Relation" of DeSoto's expedition to Florida, in 1538, mentions *Batatas*, then growing in the Island of Terceira (belonging to Portugal).

Cieça de Leon, who was in Peru in 1547, speaking of the fertility of the valleys near the Pacific coast, and the plants cultivated by the Indians, names among these, sweet potatoes (Chron. del Peru, c. 66). In the Quichuan language they were called *apichu;* in the dialect of Quito, *cumar*. Mr. Markham, in a note to his translation (Hakluyt Soc., 1864, p. 234) mentions, on the authority of Dr. Seemann, "the curious and interesting fact that *kumara* is also the word for sweet potato in Tahiti, the Fiji Islands, and New Zealand." Garcilasso says these roots "which the Spaniards call *batatas* and the Indians of Peru *apichu*," are of four or five different colors, etc. "The *least good* are those that have been *brought from Spain*."

Jean de Lery found them in Brazil in 1557, and described them under their Tupi name—*Hetich*, as he wrote it—of which "the soil of Brazil is as prolific as that of Limousin or Savoy is of rapes." He describes the Indian method of planting; yet, "since these roots are the principal article of food of this country, and are met with by travelers in various places, I judge that *they grow spontaneously*" (Hist. Navig. in Brasil, p. 165). Montoya (Tesoro, 1639) gives the Tupi-Guarani name, *Yetĩ*, and mentions numerous varieties.*

Monardes, in the third part of his Simpl. Medic. ex Novo Orbe, published in 1574 (translated by Clusius, ed. 1593, p. 439) states that *Battatæ* "are now *so common in Spain*, that ten or twelve caravel loads are sent annually from Velez-Malaga to Seville."

DeCandolle (who has elsewhere printed a short article upon the subject) calls attention to the fact, which ought to be familiar, that sweet potatoes are roots, not tubers, and that Turpin long ago published good figures illustrating this; also that while these roots are free from acrid or noxious qualities, all the Convolvulaceæ with tubers, of which there are many, and not a few of large size, are inedible and acrid,—mostly as we know, violently purgative.

Manihot utilissima, Manioc, Cassava-plant.—DeCandolle assigns good reasons for concluding (as did Robert Brown, without giving his reasons) that this important food-plant of the

* Hans Stade, who was a captive in Eastern Brazil in 1549, briefly mentions these "roots called *Jettiki*, of pleasant taste." (Captivity, Hakl. Soc. ed., p. 166.)

tropics is American, not African. But he leaves unnoticed the convincing fact that *Manioc* and *Manihot* are Brazilian names, slightly corrupted, of a plant cultivated in St. Domingo and Cuba before the landing of Columbus, and which became known to Spanish and Portuguese discoverers before 1500, by its Haytian name, *yuca*, or *hiucca*.

Peter Martyr (1493) describing the food of the islanders, names "*Iucca*, from which they make bread" (Dec. i, lib. 1, p. 7; ed. 1574); in the third book of his second decade (p. 148) he mentions "*Iucca*, *Ajes* and *Maiz*, as the three plants used by the natives for bread; in the third decade (lib. 5, p. 262) he describes the mode of propagation by cuttings, of cultivation, and of the preparation of "Cazabbi" from the root: and he states that "there are many kinds of *iucca*" (p. 263). Oviedo (*Hist. Gen. y Nat.*, lib. 7, c. 2) describes "the bread of the Indians that is called *caçabi*," which is "made from a plant they call *yuca*," and he distinguishes two species of the plant. Acosta (*Hist. of the Indies*, transl. by E. G.; Hakluyt Soc. ed., p. 232), 1588–90, gave a good account of the plant *yuca*, and the kind of bread made from it, called *caçavi*.

Peter Martyr (Dec. iii, lib. 9, p. 301) relates the Haytian tradition of the origin of the cultivation of *yuca* in their island. "They say that a *Boitius* [i. e. *magus*, or diviner], a wise old man, after the lapse of many years, saw, on the banks of a river, a plant that was like a cane; pulling it from the earth, he made this wild plant a cultivated one. He who first ate the *Iucca* raw, quickly died. But because its taste was sweet, they determined that a way of using it should be diligently sought for. When roasted or boiled, it was less hurtful. At last they came to the knowledge of the latent poison in its juice," etc.

Gomara (*Hist. gen.*, c. 71), Acosta (*Hist. nat. y moral de las Indias*, 1588–90; lib. 4, c. 17), Monardes (*De Simplicibus medic.*, transl. by L'Ecluse, 1593, p. 437), and other writers of the 16th century gave good descriptions of the plant *yuca*, and of the *caçavi* or *cazabi* prepared from the root. By the blunder of European editors, in the last half of the 16th century, the Haytian name was transferred from the plant to which it belonged to one of another order, the *Yucca* of Linnæus and of modern botany. The mistake was pointed out by Lobel.

Jean de Lery (*Hist. Navig. in Brasil.*, c. 9) describes the two species that were cultivated in Brazil in 1557—under their Tupi names, *Aypi* [*M. aypi* Pohl] and *Maniot* [*M. utilissima*]. Marcgrav (*Hist. plant. Bras.*, p. 65) mentions many varieties of both species, and gives *Mandioca* as the name of the root, *Mandiba* or *Maniiba* for the plant. Of the products of the root, Cassava retains its Haytian name (*caçavi*) nearly; Tapioca is a corruption of the Brazilian (Tupi) *tipioca* or *tipiocui*.

Dioscorea sativa, alata, etc. Yam.—DeCandolle informs us that these species, or their allies, are wholly unknown to botanists in a wild state; that, although cultivated in the East Indies, they have no Sanscrit names; that they seem not to have been widely cultivated in Africa, but that the authors of the 17th and 18th centuries speak of them as widely diffused over the South Pacific islands, from Tahiti to New Caledonia and the Moluccas. In the summary they are assigned to Southern Asia (Malabar? Ceylon? Java?), and to the eastern Asiatic archipelago. Although a large part of the genus is indigenous to tropical America, it is thought that the cultivated species were probably introduced from the Old World. The following presentation of the evidence, as concerns America, may set the question in a different light:

The natives of Cuba and St. Domingo, when Columbus discovered those islands, cultivated two kinds of plants, for their roots. These were called, in the language of the islanders of St. Domingo, *Ages* or *Ajes*, and *Yuca*. Neither of these plants was known to the Spaniards. About *Yuca* there is no question; it was the *Manihot*, or Manioc, of which we have already discoursed. It is nearly as certain that the *Ages* was a species of *Dioscorea*, to which, in their ignorance of the language of the islands, the Spaniards at first gave the name of *Ñame*, *Niame*, *Igname*, *Inhame*, or other corruptions of a foreign (probably African), name; and this name seems to have been occasionally misapplied both to the *Yuca* and the *Batata*.

L'Ecluse, who had traveled in the south of Spain and in Portugal, in 1563, says that the *Colocasia* (*C. antiquorum*) "first brought from Africa, was common in many places in Portugal, near streams of water, that it was sought for by negro slaves in Portugal, who ate it both raw and cooked," and that it was "called by the Portuguese, following the Moors, *Inhame*,—by the Andalusians, *Alcolcaz*," etc. (*Rarior. Stirpium Hist.*, p. 299.) In a note to his translation of Garcia ab Horto (1574, p. 217), he says that "the plant called *Inhame* by the Portuguese has very broad leaves, and grows near the water, or in water,—not spontaneously, but when once planted it propagates itself from the roots," etc.

Some of the companions of Columbus had seen the *Inhame* (or *Ñame*) in Africa, and were ready to transfer its name to the first cultivated roots they saw in America. A few days after the discovery of Cuba (Nov. 4, 1492), Columbus saw fertile fields "full of *mames* ['these are *ajes* or *batatas*,' notes Las Casas], which are like carrots (zanahorias), and other plants, including kidney-beans and beans (faxones y fabas) much unlike ours." (Navarrete, *Colec.*, i, 200.) These *mames* are mentioned again, Nov. 6 (*id.*, 203)—in both places, probably by

an error of the copyist, for *niames;* for, the next month, some natives of Hispaniola brought "bread of *niames*, which are roots that grow as large as rapes (rábanos) which they plant and cultivate in all their fields, and on which they live; and they make bread of them, boil them, and roast them; and they have the taste of chestnuts, and no one eating them would believe they were not chestnuts" (*id.*, 238). A few days later, the Spaniards learned the name of these roots—or of others with which they were at first confounded. The Admiral sent a present to a friendly cacique. The officer who carried it reported, on his return, that "all this island (St. Domingo) and Tortuga are cultivated like the country about Cordova. The lands are planted with *Ajes*—which are little shoots (ramillos) that are planted, and at the bottom of each grow roots like *zanahorias*, which they use for bread," and these roots "are very savoury, and taste like chestnuts." "They have them here larger and better than he had seen in any place; for, he said, he had [seen] such also *in Guinea*" (*id.*, p. 242). Again, the natives "brought bread made of *niames*, which *they* call *Ajes*" (*id.*, 251); and, Dec. 26, they gave the Admiral a "collation, of *two or three kinds* of *Ajes*, and of their bread that they call *cazavi*," etc. (*id.*, 263). After this the name of *niames* gives place to *ajes* (or *ages*). On the second voyage of Columbus, the natives, near Isabella (in St. Domingo), brought great quantities of "*ages* which are like rapes (nabos) very excellent eating," and "this *age*, the natives of Caribi (the Caribbean Islands) call *nabi*, and the Indians [of Hispaniola?] *hage*" (*id.*, 368, 369).

In two or three of the passages to which reference has been made—particularly those in which bread is mentioned—the Spaniards seem to have confounded the *ages* with the product of the *yuca* (Manihot) or to have included both under the general name of *niame* (or its equivalents, *Ñame*, *Igname*, etc). Amerigo Vespucci—or some one of the several translators through whom the relation of his first voyage comes to us—says, that in 1497, "the common food of the natives of Paria was the root of a certain tree (arborea radix quædam), which they reduce to a good enough flour, and that some call this root *Iucha*, others *Cambi*, but others *Ignami*" (Navarrete, *Colec.*, iii, 216).*

This confusion of names, in the first decade of discovery in America, was natural and unavoidable. The foreign name, *niame*, *igname*, was applied without much discrimination to roots cultivated by the natives of the islands and the mainland

* It is to this passage that Humboldt refers, in Nouv. Esp., 2d ed., ii, 468 (cited by M. DeCandolle, p. 63), as evidence that the name *Igname* was heard on the continent of America, by Vespucci, in 1497; but, as will be seen, Vespucci (or his copyist) does not say that this name was used by the *natives*.

—primarily, to *ajes*, occasionally to *yuca* (Manihot), and perhaps to *batatas*. In the relations of the voyages of Columbus only *two* cultivated roots are named—*Ages* and *Yuca*. The first book of Peter Martyr's first decade (dated 1493, but probably revised before its publication in 1511), names only these two; and in the third book of his second decade he mentions the use of the same two roots by the natives of Comagra, in Darien (p. 148); but in a subsequent chapter (dec. ii, c. 9., p. 191), he adds—as has been mentioned in a preceding note—a *third* kind of roots, which the natives of the province of Darien call *Batatas*, that grow in their country spontaneously. From this date to the middle of the 16th century the distinction between these roots, though occasionally lost sight of, is generally observed. Oviedo (*Hist. Gen.*, l. vii, cc. 2, 3, 4; p. 268–73), describes the *caçabi* and two species of the plant (*yuca*) that yields it; *ajes*; and *batatas*. The *ajes*, he says, were cultivated in Hispaniola, and in all the other islands, and on the continent; they were of various colors—white, reddish, inclining to mulberry, and tawny, but all white within, for the most part; the stem of the plant extends itself like that of correhuela (*Convolvulus* or Bindweed), but stouter; the leaves cover the ground, and are shaped much like correhuela and nearly like ivy or panela, with some delicate veins (unas venas delgadas), and the little stems (astilejos), on which the leaves hang, are long and slender, etc. The leaf of the *Batata*, he says (p. 274), is more toothed or notched (*harpada*) than that of the *Aje*, but of nearly the same fashion; and the two plants are much alike, but the *Batatas* are sweeter and more delicate, etc.: some of the *Ajes* weigh four pounds each, or more. In some parts of Castilla del Oro (in Darien), there are *Ajes* that are small and yellow, etc. (p. 273). His description of the two plants permits no reasonable doubt that his *Ajes* were of the genus *Dioscorea*. Moreover, they were not identical with—though they resembled—the imported *ñame* or "yam:" for Oviedo states (*Hist. Gen.*, lib. vii, c. 19, p. 286), "that *name* (called *nnames*), is a foreign fruit, not natural to these Indies, which has been brought to Hispaniola and other places, and is suited to this evil race of negroes, and a profitable and good subsistence for them. . . . . These *nnames* seem to be *ajes*, but are not the same, and generally are larger than *ajes*." They had already multiplied greatly in the islands and on the mainland.

The distinction between *Ajes* and *Batatas*, though clearly apprehended, was sometimes lost sight of. Peter Martyr (dec. iii, lib. 9, p. 302), says that "the species of *Ages* are innumerable—the varieties being distinguished by their leaves and flowers;" and he gives the American names of nine of the

varieties; but five of these nine are named by Oviedo (p. 274), as varieties of *Batatas*. [See *Batatas*, ante.]

The "Gentleman of Elvas," who wrote the narrative of DeSoto's expedition, mentions a fruit, at Santiago, Cuba, called *batata*, the subsistence of a multitude of people, principally slaves, and which now (1538) grows in the island of Terceira, belonging to Portugal. . . . . It looks like the *ynhame*, with nearly the taste of chestnuts" (*Relaçam Verdadeira*, ch. 5).*

Jean de Lery, who was in Brazil in 1557, though he gives a good description of the *Batata*, does not mention the Yam; but it is figured and described by Piso (*Hist. Nat. Brazil*, 1648, p. 93), as *Inhame* of *St. Thomas*, called *Cara* by the natives of Brazil, and *Quiquoaquecongo* by the Congo negroes. Ruiz de Montoya has the name *Cará* in his Tupi dictionary, 1639, and mentions five varieties. As the Tupi name for the Virginia potato (Solanum tuberosum) *Carati* (i. e., white yam), is formed from that of the Inhame, it would seem that the latter was of earlier introduction. So, in the Mpongwe—a language of the Congo group—the potato is called *mongotanga* 'white-man's yam.'

Portulaca oleracea, Purslain.—Botanists have taken it for granted that this weed of gardens and other cultivated grounds was transported to America from the Old World. But Nuttall found it apparently indigenous on the upper Missouri forty years ago, and Dr. James in Long's Expedition, along the eastern base of the Rocky Mountains in what is now the State of Colorado. From thence to Texas it grows wild along with two other nearly related species. Moreover the following evidence tends to show that its introduction, if introduced by human agency, took place before the landing of Columbus.

On their first sight of the new world, the Spaniards were much impressed by the strangeness of all forms of animal and vegetable life: "all the trees are as unlike ours, as day is to night"—wrote Columbus, Oct. 17th, 1492, six days after landing at San Salvador: "and so are the fruits, and so the plants, and the stones, and all things" (Navarrete, i, 183). On the 28th, on the north shore of Cuba, he saw—apparently for the first time—a familiar plant: "*halló verdolagas* muchas y bledos," —he found much *purslane* and *bletum* (*id.* 192). It seems hardly possible that the Admiral and his companions could mistake a strange plant for a salad herb so well known as "verdolagas" to Spanish eyes and palates. Again, Oviedo, writing about 1526, in a list of "plants in the island of Hispaniola which are like those of Spain, and which were before

* In one Indian language of the south, the Choctaw, the sweet potato is now called *ahe;* while the Virginia potato (S. tuberosum), takes the adopted prefix of "Irish," *Ilish ahe*, or is sometimes called *ahe lumbo* 'round *ahe*.'

the Christians came to these parts, and are natives of this land, and were not brought from Spain," names "verdolagas or *pertulaca*" and "bledos or *bletum*" (*Blitum*).

In his description of "perebeneçuc," written in 1525, he says, that plant grew, in great abundance, in Saint Domingo and in many places on the continent, in the woods and fields; even "purslane (*verdolagas*) is not more abundant here" (*id.*, lib. xi, c. 5, p. 378.)

Jean de Lery, in Brazil in 1557, was as much impressed by the novelty of the flora, as Columbus had been, in the West Indies. "I declare," he wrote (*Hist. Navig. Brasil.*, 168), "as far as it was permitted me to discover in wanderings through the woods and fields, that there are no trees or plants, or any fruits, that are not unlike ours, these three excepted, *portulaca*, ocymum and filex" (in the original French edition, 1578, p. 217, "*pourpier*, basilic, et fougière.").

Capt. John Smith, in Virginia in 1606, found "many herbes in the spring, commonly dispersed throughout the woods, good for broths and sallets, as Violets, *Purslain*, Sorrell, etc.; besides many we used whose names we know not" (Smith's *Gen. History*, 1632, p. 26; and repeated by Strachey, *Travaile into Virginia*, p. 120). Smith's *purslain* was probably *Sedum ternatum*.

Sagard-Theodat, in the relation of his *Grand Voyage du Pays des Hurons*, in 1624 (p. 331), says that the Hurons make little use of herbs, "although the *pourpier* or *pourcelaine* is very common there, and grows spontaneously in their fields of corn and pumpkins."

W. Wood, who was in New England from 1629 to 1633, names "Purselane" among plants growing "in the woods, without either the art or the help of man" (*N. E. Prospect*, pt. 1, c. 5). We doubt its growing literally in the woods, as unlike its natural habit, and place more confidence in the statement of Champlain, who, in his earlier voyages, 1604–11, found plenty of excellent *pourpier*, for his salads, on the coast of New England, growing among the Indian corn; "the savages making no more account of it than if it were a noxious weed" (*Voyages*, ed. 1632, p. 80).

Humulus Lupulus, Hops.—Although the matter has nothing to do with the introduction of hops into cultivation, it is noticeable that DeCandolle assigns the home of the plant only to Europe and Western Asia. It is undoubtedly indigenous to North America also, and is mentioned as such in the American works. In Gray's Manual, besides the printing of the name in the type appropriate to indigenous species, the plant is expressly stated to be "clearly indigenous." But, through some oversight, in the Prodromus (xvi, 29), it is stated, in connection with this very reference, that the plant was introduced.

Oca.—Considering that *Maté* and *Coca* find place in this volume, although perhaps rather employed than cultivated (at least the former), the absence of *Oca* (*Oxalis tuberosa* and *O. crenata*) is noticeable. This esculent root deserves mention, if only for the antiquity of its culture in Peru. The name, which is Quichuan, appears to have belonged, specially, to *Oxalis tuberosa*. Another root "like the *oca* in shape, but not in taste," called in Quichua *añus*, was less esteemed. Both were cultivated in Peru in the time of the Incas, and in the districts where no maize grew, the crop of these tubers was of much importance (Garcillaso, *Comment.*, b. v, c. 1; b. viii, c. 10.) J. de Acosta, 1588–90, says "there are an infinite number" of roots used for food in the Indies, "but the *Papas* (potatoes) and *Ocas* be the chief for nourishment and substance" (*Nat. and Moral Hist. of the Indies*, lib. iv, c. 18).

Our notes upon plants cultivated for their herbage, tubers, roots, etc., have run to such a length, that the remainder, concerning some plants cultivated for their fruits and seeds, must be left for another article.

ART. XXVIII.—*Remarks on Glyptocrinus and Reteocrinus, two Genera of Silurian Crinoids;* by CHARLES WACHSMUTH and FRANK SPRINGER.

IN the second part of our Revision of the Palæocrinoidea, at page 185, and following, we undertook to define the character and relations of *Glyptocrinus* and allied genera, in such a manner as to render it possible to group the species thereunder with some approach to their natural order. As is well known to every one who has attempted to identify the species, the American Silurian Crinoids are an extremely difficult group to understand. There are a few well marked species, of which ample collections have been made in Ohio and Indiana, but a large number of species have been described by Billings, Hall and others, from very meagre and imperfect material. Of many of these forms specimens are exceedingly rare, and we are often obliged to rely upon illustrations which are unsatisfactory, and descriptions which are necessarily defective in the delineation of specific and even generic characteristics. Under these circumstances it was scarcely to be expected that our conclusions would prove entirely satisfactory, even to ourselves.

Our treatment of the genera *Glyptocrinus* and *Reteocrinus* has been somewhat sharply criticized by Mr. S. A. Miller, in the Journal of the Cincinnati Society of Natural History for April, 1882, in connection with the description of some new species un-

der the first name. He objects to our definition of the characters of the former, to our rectification of the latter, and to our reference of species thereto. He also intimates that we have taken unwarrantable liberties with Billings' genus, and been guilty of a lack of proper respect for the work of its founder.

We have given to the remarks of Mr. Miller the consideration that is due to the observations of a gentleman of acknowledged learning, and whose researches in the literature of this branch of Natural Science have lightened the labors, and merited the thanks of every American Paleontologist; and have reviewed the species referred to the two genera in question with the aid of somewhat better material, as to some of them, than was at our command before.

With regard to *Glyptocrinus*, Mr. Miller states that we "seem to have been practically unacquainted with the genus;" in support of which he instances the fact, that our diagnosis requires that the surface of the plates should be "ornamented with radiating striæ in the form of elevated ridges, which divide into numerous triangular, impressed areæ;" that the basals should "scarcely extend to the sides of the body;" that the second radials should be "hexagonal," the third radials "pentagonal," and that there should be "twenty arms."

It is true that we have in our diagnosis ascribed these characters to the typical form of the genus, but in singling them out as the essential characters by which we define the genus and separate it from others, Mr. Miller is either somewhat uncandid, or else he has overlooked our distinct statement, under the head of *Glyptocrinus* on pages 186 and 187, of the characters by which it is separated from *Glyptaster* on the one hand, and *Reteocrinus* on the other. When we began the systematic investigation of this group, we found an assemblage of species referred to the above named genera, in such a manner as to render the recognition of generic limits impossible. This was especially the case with *Glyptaster* and *Glyptocrinus*. After much perplexing study we recognized the three types, into which these species might be grouped somewhat more satisfactorily than before; one of which was represented by the two species described by Billings as *Reteocrinus*, but with a misconception of their true characters.

It may probably be said with justice, that in this case, as perhaps in some others, we have adhered in our diagnosis of generic characters rather closely to the particular form which we regard as typical, and have not in express terms indicated the limits to which variations of these characters may and do extend. That modifications of characters and departures from the typical form in various directions are to be expected within the limits of every genus, is a fact which we have always

admitted and repeatedly asserted. We do not know of a single genus, illustrated by any considerable number of specimens, in which there are not some forms exhibiting a variation of one or more of the typical characters, and constituting transitional forms between that and some allied genus. The same may be said of some of the best defined species, and indeed, this observation may be extended to almost every group, whatever be its rank, which naturalists have attempted to separate and define. For example, one of the best characters of *Actinocrinus* is the simplicity of the arms, which almost universally remain undivided after becoming free. Yet we find in one of the latest species, *A. Lowei*, which otherwise retains and exaggerates all the characteristic features of the genus, that some of the arms in each ray bifurcate beyond the body; and isolated specimens of other species have been found in which such a bifurcation occurs in one or two arms out of the whole number.

No method of systematic classification has as yet been devised to adequately provide for all such cases; and we do not believe it possible so to limit and define the characters of a genus, as to escape the difficulties arising from modifications due to individual growth, and the variations of types in geological time.

A modification of the phraseology of our generic descriptions of *Glyptocrinus* and *Reteocrinus*, by which the existence of certain of the less important characters, such as surface ornamentation, the number of arms, and the geometric form of plates should be stated in less absolute terms, and with greater allowance for exceptional cases, would apparently meet the objections urged by Mr. Miller on this point; and we may find it advisable to make such alterations hereafter in this and perhaps other cases. It did not occur to us that our language was liable to misconception in this respect, in view of our frequent expressions as to the value of such characters, and our explicit statement of the leading characters. We do not regard the number of arms, for instance, as an absolute specific distinction, much less generic, although it is often an *important* character in connection with others, and a useful guide to the recognition of types; but departures from the prevailing rule are of frequent occurrence in genera, species, and even in the different rays of the same individual. This fact we have time and again pointed out in our writings. (See Rev. II, pp. 40 to 50 and other places; Transition forms in Crinoids, Proc. Philad. Acad. 1878, p. 224 et seq.) These considerations, however, and any modifications we might make in our language to avoid further misunderstanding, would not in the least affect the validity of the separation of the two genera *Glyptocrinus* and *Reteocrinus*

as we have defined them, or the reference of species thereto, in any substantial respect.

Mr. Miller expresses the opinion that our "separation of the species under this genus *Reteocrinus* and that of *Glyptocrinus*, shows to one familiar with the structure such a cross mixture of character as to indicate a want of general acquaintance with the genera and species," and after referring to Billings' statement of the generic characters of *Reteocrinus*, he asserts that "up to this time no Crinoid possessing the characters ascribed to this genus has been found in the Hudson River group of this locality" (Cincinnati).

We freely admit the great advantage which flows from an intimate familiarity with the fossils at the locality from which they are derived. An accurate knowledge of the mode of occurrence and distribution of the respective species, and their association with other fossils, such as can only be gained by the collector himself, furnishes an aid to the interpretation of their systematic relations, whose importance cannot be underestimated. For this reason, upon questions relating to these genera, we attach much weight to the opinions of our Cincinnati friends, who not only are themselves collectors as well as investigators, but have access to the other numerous fine collections that have been made in that locality; and we are gratified to be able to avail ourselves of the benefit of their observations, whether critical or otherwise. In a work of the nature of ours, so beset with difficult problems in classification, we do not expect to be exempt from error and shall be only glad if others are led to the investigation of these questions independently, because we are sure that by the operation of different minds, considering the subject from other points of view, and with other material than ours, a nearer approach to correct results will be gained.

When it appears, however, that the two leading naturalists of Cincinnati, after such critical study of the subject as is necessary to enable them to describe new specific forms, have reached conclusions diametrically opposite with regard to the characters and relations of *Reteocrinus* and *Glyptocrinus*, we may perhaps be warranted in attaching somewhat more importance to the results of our own studies, which we can see no reason to think less reliable, in any material respect, on account of any thing that has been thus far advanced against them.

Prof. Wetherby, in connection with the description of his interesting species *Reteocrinus* (*Glyptocr.*) *Richardsoni* (Journ. Cin. Soc. Nat. Hist. 1880, vol. ii, Pl. 16) observes, that the different species of *Glyptocrinus* found in the Cincinnati group "naturally fall into two groups, the extremes being represented by *Gl. decadactylus* and *Gl. Nealli*;" that "these two groups are

closely united by a series of intermediate forms, of which the *Gl. Richardsoni* is the last and most important link;" and also that "the *Gl. Nealli* . . . . seems to be as closely allied to *Reteocrinus* of Billings as to *Glyptocrinus*." Afterward, in the April, 1881, number of the same Journal, Prof. Wetherby, with his new species *Reteocrinus gracilis* under consideration, makes the following statement, under the head of *Reteocrinus:* "Under this generic name, Mr. Billings described two species from the Trenton rocks of Canada, in the publication cited above. Like most of the fossils of the locality whence they were obtained, these were in a very poor state of preservation. Enough is shown, however, by Mr. Billings' figures to make it conclusive that several forms of our so-called *Glyptocrinus* should be referred to this genus. Among them I should place *Gl. Nealli* Hall, *Gl. Richardsoni* Wetherby, and the species of which the description is to follow" (*Reteocr. gracilis.*) This opinion of Wetherby was before us when preparing the second part of our Revision for the press, both in its published form, and more at length in private notes, and as he could scarcely be said to be "practically unacquainted with the genus," we naturally attached much importance to it as a confirmation of our own views.

Furthermore, Meek, in re-describing "*Gl. Nealli*" in the Paleontology of Ohio, vol. i, p. 34, and having before him at the time many of the finest Cincinnati collections, alluded to the characters of this species as "showing a decided approximation toward *Reteocrinus* of Billings."

These extracts will be sufficient to show that so far as authority, and the discoveries of the latest and most competent observers, could furnish a guide, we were fully warranted in referring *Gl. O'Nealli* and allied species to *Reteocrinus.* A consideration of what we have stated in our generic descriptions, and our repeated allusions to these two genera in the discussion of family relations, will also show that we made such reference after due deliberation and careful study, and for reasons still more conclusive than those stated by the above mentioned authors. We have considered *Glyptocrinus* a form of the utmost interest and importance, and have made it the foundation of our discussion of the family relations of the Actinocrinidæ and Rhodocrinidæ.

Let us now endeavor to ascertain what the *Reteocrinus* of Billings really is; and we wish to state in this connection, that we yield to none in admiration for the work done by E. Billings in fossil crinoids. He was continually embarrassed by the poverty of his material, and the wonder is not that he made mistakes, but that he made so few. His excellent judgment, keen discrimination and scientific methods, we have

reason to appreciate, not only from his published works, but from an extended correspondence with one of the writers during the preparation of his admirable articles on the structure of Crinoidea, Cystidea and Blastoidea, in 1869.

Billings established his genus *Reteocrinus* upon two species, *R. stellaris* and *R. fimbriatus*, which are described in Decade iv, of the Geol. Surv. of Canada, pp. 64 and 65, and illustrated on pl. ix, figs. 3, 4. Of *R. stellaris*, which he took for the type of the genus, he had four specimens, three of which were fragmentary, and all of them in such a poor state of preservation, that Billings himself says at the end of the description, that "none of the specimens collected are perfect, and the characters of the species, therefore, have not been fully ascertained." The interradial spaces were very deeply depressed and filled with a hard matrix of limestone, which concealed from view the whole interradial portion of the calyx, with the exception of some small stellate points, which are now known to be the projecting summits of the plates. His principal specimen, fig. 4*a*, was so imperfect that Billings seemed to think that the ridge-like series of anal plates on the azygous side might possibly be an arm, and that there might be six (primary) arms in the species, although the generic description calls for but five primary radials. He considered the plates following the first primary radials to constitute arms, and found that the right (left posterior) of these "arms" divided on the fourth joint, but the others he could not see distinctly. The genus, of which this was the best specimen of the typical species, he considered to have "no perfectly formed plates," and its cup to consist of a "reticulated skeleton, composed of rudimentary plates, each consisting of a central nucleus, from which radiate from three to five stout processes," (Dec. iv, p. 63), characters which do not exist, as subsequent investigation of the type specimen has fully demonstrated.

R. fimbriatus, the second species, was described from a single specimen, Dec. iv, pl. 9, fig. 3*a*, and this, as Billings states, is "very imperfect." There is enough, however, in his figure and description to show, that in the opinion of the founder of the genus, a species having a pentagonal column; the "basals" (underbasals of our terminology) minute; the "subradials" (basals) one line in height; the arms several times divided (but only once in the body); a bifurcation on the third primary radial; and the spaces between the rays "*filled with very small plates*," might properly be referred to *Reteocrinus*. These characters apply equally well, and with scarcely any variation, to the so-called *Glyptocrinus O'Nealli* Hall, *G. cognatus* Miller, *Gl. Bœri* Meek, and *Reteocrinus gracilis* Wetherby, and with the exception of the column, to *Gl. Richardsoni* Wetherby, *Gl.*

Pattersoni Miller, and *Gl. subglobosus* Meek, all from the Hudson River Group at or near Cincinnati; and this may be taken as a sufficient answer to Mr. Miller's statement, on page 13 of the author's edition of his paper before cited, of the essential characters of *Reteocrinus*.

In 1869, in a letter to one of the writers, Billings himself stated that *Glyptocrinus O'Nealli* was certainly not a *Glyptocrinus*, and indicated its probable relationship to *Reteocrinus*. Unfortunately we are unable to find his letter, or we should quote his exact language.

In order to obtain, if possible, some additional information as to the exact condition and character of the typical specimens of *Reteocrinus*, we applied to Mr. Walter R. Billings, of Ottawa, Canada, a nephew of E. Billings, and himself a very acute observer and ardent naturalist, and requested him to examine the original types deposited in the Museum of the Canadian Geological Survey, and advise us of the facts. This Mr. Billings has done, with an intelligence and care which merits the highest commendation, and a generous kindness for which he has our warmest thanks. We quote the following extract from his letter of July 10th, 1882:

"Your communication contains an uncleaned but very perfect specimen of *Glyptocrinus O'Nealli* Hall, (*Reteocrinus O'Nealli* of Wetherby, Wachsm. and Spr., and others) with a request that I compare it with the type specimen of *Reteocrinus* in the Canadian Survey Museum, and inform you as to the facts. Prof. Whiteaves, Palæontologist G. S. C., with his characteristic kindness, granted me full permission to examine the type specimens of *R. stellaris*, and I have given special attention to those figured in Decade iv, G. S. C., as 'figs. 4*a*, 4*d*.' Both these specimens are obscured by a hard adherent matrix, which in so valuable specimens would require a skilled lapidary to remove; however, with a soft brush and a little moisture, I readily removed small loose portions of shale, and made the determination of the leading points easy.

"The column is as originally described.

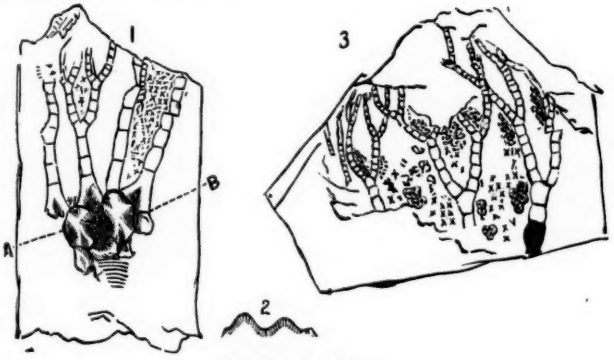
"In the specimen figured '4*d*,' I find a series of five (5) subequal plates, resting on the column, each bearing a bow-shaped ridge with sinus upward, not in contact with the margins, except where it meets corresponding ridges on the succeeding plates above; the remaining portions of these plates are depressed from $\frac{1}{3}$ to $\frac{3}{4}$ of a line. The plates of the second order alternate with those of the first (two are tolerably well shown on the specimen 4*a*), and are heptagonal, resembling a hexagon slightly truncate, they have ridges corresponding with, and forming continuations of, those on the plates below, which meet in the center, and divide to become continuous with

ridges on the succeeding series of plates. The plate of the azygous side has three ridges passing upward; one from the center to become continuous with a ridge following the median part of the azygous interradius; the remaining two, which are directed obliquely, meet with similar ridges on the adjoining plates of the third order. The depressions between the ridges of the plates of the second order extend slightly to the plates of the first and third order; they are deep, especially the larger one at the azygous side, which has a depth of $\frac{1}{4}$ of a line. The plates of the third order, which alternate with those of the second, are radial in position, and support in an upward direction a row of other plates with strong, rounded, arm-like ridges, which in the specimen resemble closely arm plates, as which they were described by E. Billings. They are, however, evidently radials with elevated ridges, similar to the primary radials of *Gl. O'Nealli* Hall, which, like these, were connected laterally by interradial plates, and formed a part of the calyx. This is indicated by the numerous stellate pieces interspersed between the ridges, which in all probability represent interradial plates, of which only the elevated central portions are exposed to view, while their depressed margins are obscured by matrix. These stellate pieces are continued as high as the third plate of the secondary radials, and I have observed one within the axis of the first bifurcation to the left of the azygous series, thus indicating that the body in this species is not confined to the three lower angles of the plates, as suggested by E. Billings, but that it extended to the secondary radials.

"So far as the imperfection of the material will admit of comparison, there is a strong resemblance between *Reteocrinus stellaris* and *Glyptocrinus O'Nealli* Hall, which extends not only to the arrangement and form of first, second and third ranges of plates, but to the entire radial and interradial series, in view of which, and in the absence of any points of more than specific distinction, I am led to think the two forms congeneric.

"In addition to the two specimens on which these remarks have been founded, and to those figured in Pl. 9, Dec. iv, G. S. C., there is in the G. S. C. collection a flattened specimen, showing the side opposite to that shown in fig. 4*a* (loc. cit.), but wanting the first three ranges of plates, leaving the identity of the species not quite positive. This specimen (fig. 3, infra), has the interradial series more clearly and fully shown, and is filled with stellate pieces as high as the third secondary radials, below which they are interspersed with smaller and flatish plates, which grow smaller above, and disappear either lost in the matrix or through preservation. At one point at least, these small plates are seen to be continued with the arm pieces; they may represent the vault, and if so, this is another point of resemblance to *Gl. O'Nealli* Hall."

In addition to the above expressed details, Mr. Billings has furnished us drawings of the type specimen (fig. 4*a*), as it appears after being somewhat developed by cleaning, which shows that the three lower ranges of plates, instead of being "rudimentary," are perfectly formed, connected with each other by distinct sutures; much elevated in the middle and marked with strong radiating ridges, and having greatly flattened wing-like margins, which were before obscured by the matrix. He also figures the flattened specimen referred to in his letter, but not figured in the Canada Reports.



Reteocrinus Billings.

Fig. 1. Billings's type specimen (Geol. Rep. Can., Dec. iv, Pl. 9, fig. 4*a*). Fig. 2. Section A–B, to show depression of margins of plates. Fig. 3. Specimen in G. S. C. collection not figured before. All from drawings by Walter R. Billings.

We think that with these figures, and the notes above quoted, the question of the generic identity of *Gl. O'Nealli*, and allied forms with *Reteocrinus*, may be considered at rest.

By following the strict letter of the rules of nomenclature, we might have been justified in setting aside Billings' genus entirely, and re-describing the type under a new name, for the reason that the leading characters ascribed to it as generic, do not in fact exist in his own species or elsewhere. This has been partly done both by Zittel and De Loriol, neither of whom recognize *Reteocrinus* at all. But the true spirit and intent of the rules of scientific nomenclature do not require such a course. We consider it far more just to the original observer, who has called attention to a new generic type, to assign to it the true characters as disclosed by subsequent investigation, and retain the genus so modified as to include such forms as are naturally congeneric with the species first described, than to deprive him, by a technical adhesion to a strict rule, of all credit for his work, and burden science

unnecessarily with new names. If under these circumstances it happens, that the true characters of the group are better and more comprehensively expressed in some other species than the one first described, there is, in our opinion, not the least objection to adopting it as the type of the genus thus rectified. And where the original species is imperfectly known, this is the only rational thing to do, because we cannot well take, as the type of a genus, a species which is not itself accurately defined. The rules are intended to promote accuracy and clearness in scientific determinations. We do not believe they require absurdities, but if any of them does, the sooner it is abrogated the better.

Mr. Miller thinks that in making *Gl. O'Nealli* the type of *Reteocrinus*, we have been guilty of an "open violation of the rules of nomenclature." We think our practice in this respect fully justified by the consideration above stated. At all events we shall adhere to it, and we find that other good authorities do the same thing.

A few words now as to the relations of these two genera. At various places in Pt. II, of our Revision, for example pp. 7, 95, 183–187, we have alluded to the intimate relation which exists between the families Rhodocrinidæ, with two rings of plates below the radials, and Actinocrinidæ with but one. We have shown how *Glyptocrinus* with its rudimentary under-basals, and its interradial series, all above the line of the first radials, formed a connecting link between the two families, approaching the *Rhodocrinus* type in the first character, but in the second departing from all other genera of that family, and exhibiting an approach to some of the earlier forms of the Actinocrinidæ. Its close affinities with *Reteocrinus*, with which we stated (p. 183), it to be "connected by most remarkable transition forms," led us to refer *Glyptocrinus* to the Rhodocrinidæ, although there were almost as good reasons for referring it to the Actinocrinidæ. It might perhaps have been well to place it in a section by itself, on account of the exceptional disposition of its interradials.

It is an important fact that in all Actinocrinidæ, without a single exception, the regular interradial series rest upon the edges of the first radial plates, and are not extended down to the basi-radial suture. In the Rhodocrinidæ, the first interradial and anal plates all rest upon the basals, except in *Dimerocrinus*, *Glyptaster*, *Eucrinus*, *Lampterocrinus* and *Glyptocrinus*. In the first four of these genera, the anals rest upon the basals, though in *Dimerocrinus* the regular interradials sometimes barely touch them. *Glyptocrinus* is the only genus of the Rhodocrinidæ in which neither the anal nor interradial plates are in line with the first radials, or in contact with the

basals, and it is this character, as far as we can discover, which distinguishes it best of all from *Reteocrinus*, and upon which a few species of the type of *Gl. decadactylus* can be satisfactorily grouped. Of the species which we referred to *Glyptocrinus*, it will be observed that *Gl. fimbriatus*, *Gl. nobilis*, *Gl. Shafferi*, and *Gl. subglobosus* were mentioned as doubtful for reasons there stated, and had our printed copy corresponded with our original notes, *Gl. ramulosus* and *Gl. ornatus* would have been noted with like reserve, owing to the impossibility of accurately determining their characters from the specimens described. Of these we have become satisfied that *Gl. subglobosus* is a *Reteocrinus*, very closely related to *Gl. Bœri*, and *Gl. Shafferi* and its variety *germanus* are evidently immature specimens, as to whose generic characters we are unable to satisfy ourselves from the figures and descriptions. *Gl. ramulosus* is probably an *Archæocrinus*. In *Gl. ornatus* the figure shows the upper parts to be so obscured by the matrix, and the base to be so imperfect, that we cannot pass an opinion on it.

Of the remaining species, *Gl. angularis* is a departure from the typical form in the direction of *Glyptaster*, to which, or more likely to its subgenus *Eucrinus*, it might, perhaps, be advisable to refer it. *Gl. priscus* is a young *Glyptocrinus* with strong transitional characters toward *Reteocrinus*. The highly elevated connecting ridges on the larger plates are very similar to the so-called "processes" of Billings' *Reteocrinus stellaris*. *Gl. parvus* is apparently a young example of a typical *Glyptocrinus*, which therefore has the basals comparatively large, but as the anal side is unknown, it is not wholly free from doubt. Of *Gl. Fornshelli* we unfortunately have not the description. Miller's *Gl. Miamiensis*, Cincin. Journ., April, 1882, is apparently a *Glyptocrinus* with variation of characters toward *Reteocrinus*. The genus is therefore typified by *Gl. decadactylus*, *Gl. Dyeri*, Miller's new species *Gl. sculptus*, and probably *Gl. parvus*, whose characters are, as stated in our diagnosis, to wit: a sculptured surface; rudimentary underbasals; small basals; the interradial and anal spaces occupied by plates of definite arrangement, all located above the line of the first radials, and nearly equally distributed among all five rays; and twenty arms. And if we further state that the body plates are "generally" ornate, and that there are twenty arms "as a general rule," it will enable us, without offending against any requirement of critical accuracy, to bring within its limits those transitional species above mentioned, which seem to be nearest to its type. *Reteocrinus* is readily identified by its highly elevated radial ridges and depressed interradial spaces, filled with numerous small plates of irregular arrangement, and extending between the first radials down to the basals; by its under-

basals, often well developed; its strongly marked bilateral symmetry; and by its ten primary arms as a rule. It is typified by *Reteocrinus O'Nealli, R. cognatus, R. gracilis, R. stellaris, R. fimbriatus;* while *R. Richardsoni, R. Bœri, R. subglobosus* and *R. Pattersoni*—the latter described by Miller as a *Glyptocrinus*, Cincinn. Journ., July, 1882—are good examples of it in every respect, except that the underbasals have not as yet been noticed, and perhaps do not exist; although we think it very probable that they may be found to possess these plates in a more or less rudimentary form as in *Glyptocrinus.* We do not consider it necessary or advisable to separate these species from the typical form upon this character alone, since the whole assemblage of species above named forms a group, which is united by other well defined characters. The slight modification of our statement of generic characters renders it easy and natural to include them all.

In the Cincinnati Journal for April, 1881, Mr. Miller described two very interesting aberrant species from the Lower Silurian near Cincinnati. One of these, *Gl. Harrisi*, is a *Glyptocrinus* with a quadrangular column and, possibly, quadripartite base, and having the anal series, as we learn from the figures, extended down to the basals. If it has in fact four basals, it would be a good *Mariacrinus*, were it not for the position of the first anal plate, which is not in contact with the basals in any of the *Melocrinites;* or it would have the calycal structure of *Abacocrinus* without the other characters of that genus; showing thus a tendency toward the Actinocrinidæ. If on the other hand it has five basals, it would represent a variation from the *Glyptocrinus* type in the direction of the Glyptasterites, without however any development of underbasals. The other species for which Miller has established a new genus, *Xenocrinus*, has a quadrangular column and four basals; surface devoid of ornament; the radials highly elevated; interradial spaces deeply excavated and filled with a great number of small irregular plates; ten arms; bilateral symmetry; and no underbasals as yet observed. So far as we can judge from the figures (Journ. Cincinn. Soc., April, 1881, Pl. I, figs. 3*a*, 3*b*, 3*c*; and July, 1881, Pl. IV, fig. 6), all the interradial series rest upon the basals, although the description is silent as to this character. It is, therefore, a *Reteocrinus* with four basals, and represents a differentiation of the *Glyptocrinus* type toward the Rhodocrinoid form, with the basal characters of the *Melocrinites* section of the Actinocrinidæ. We think Miller was perfectly correct in referring it to a new genus, and in case the *Gl. Harrisi* should prove to possess a quadripartite base, and the discovery of other specimens shows this character to be constant, we should be disposed to adopt the same course with that form.

Mr. Miller considers it probable that *Gl. Harrisi* has five basals, because "in all other respects it agrees with *Glyptocrinus*"—not recognizing the difference in the disposition of the anal plates—but states that "if it possesses but four, it would not belong to *Xenocrinus*, but would still be very closely allied to *Glyptocrinus*." We confess we are somewhat at a loss to understand just what Miller's views are, as to the limits of this genus. He objects to our reference of *Gl. O'Nealli* and allied species to *Reteocrinus*, and at one place considers the *Gl. O'Nealli* and his own *Gl. cognatus*, and therefore necessarily *Gl. Bœri*, to be true *Glyptocrinus*. At another, in describing his *Gl. Patersoni* (Journ. Cin. Soc., July, 1882), he states that the species differs from all other species of *Glyptocrinus* in having only ten arms. We can scarcely suppose that, when making this statement, he overlooked the fact that not only the *Gl. O'Nealli* and *Gl. Bœri*, but also *Gl. cognatus* which he had himself described a year previously, have but ten arms; but we infer that he then considered these species to be generically distinct from *Glyptocrinus*. If this be not so, how can it be said that *Xenocrinus priscillus*, which is in every respect a *Gl. Bœri* with four basals and a square column, would be generically distinct from *Gl. Harrisi*? Suppose each of them had five basals; would both be *Glyptocrinus*? Evidently not, according to Miller's reasoning above quoted; and if these two forms are generically distinct by reason of characters other than those at the base, surely *Gl. Bœri* and *Gl. decadactylus*, which differ in precisely the same way, must be.

A reinvestigation of the genera herein discussed, and their allies, has impressed us more than ever with the idea stated frequently in our Revision, that this little group of Lower Silurian Crinoids represents an embryonic type, from which both Rhodocrinidæ and Actinocrinidæ were developed. They are among the earliest forms we know, and they stand in a similar relation to these families that *Heterocrinus* and its allies hold to the Cyathocrinidæ. In both there is the same rudimentary and varying development of characters, which when fixed and constant, become of family importance. In both are found the types of the fundamental structure of the respective families in very simple forms, whose differentiations in various directions led to the several subdivisions and genera, into which these families have been divided. Within each there is found a commingling of characters which is a source of endless perplexity to those who are seeking to discover some clew to a natural classification. We are disposed to think that a further subdivision of the families, whereby these embryonic types should be placed in separate subfamily groups, would tend to eliminate some of the difficulties we have encountered,

and to this end we shall very probably hereafter propose to arrange in a distinct group the genera *Glyptocrinus*, *Archæocrinus*, *Reteocrinus*, *Xenocrinus*, *Glyptaster* and *Eucrinus*, and possibly one or two others, so as to constitute a subfamily, intermediate between the Actinocrinidæ and Rhodocrinidæ, and through which the latter are united to form the great family Sphæroidocrinidæ.

ART. XXIX.—*On the Smee Battery and Galvanic Polarization*; by WM. HALLOCK.*

1. INTRODUCTION.

THE electromotive force of the Smee battery, when determined with the greatest care by different methods, gives values which differ greatly from each other and are larger or smaller than the theoretically calculated value, E = 0·75 D.,† according as the resistance in the circuit used is larger or smaller than about 300 or 400 S. E.† It was with a view to obtaining an explanation of this fact if possible, and to obtain further data which might help to decide between various conflicting explanations already offered, especially those of Exner‡ and Fromme,§ that the first part of this research was undertaken.

The second part has to do with the question whether the electromotive force of galvanic polarization can be computed *a priori* from the thermal equivalents of the chemical reactions which take place thereby, and is intended to check the already determined values of this force and to obtain new ones in order to collect as large a number of values as possible, to see to what extent the experimentally determined values correspond with the theoretically calculated ones.

2. APPARATUS.

Not having at my disposal an electrometer which answered all the requirements of delicacy, damping, etc., it was determined to use a galvanometer with large resistances in the circuit. The instrument used was a Wiedemann reflecting galvanometer with a coil of 17,800 turns and a resistance of 6,700 S. E. The small ring magnet had a short time of vibration (1·1 second) and was so strongly damped that it came to rest

* Being an abbreviated translation by the author, the original having appeared in Wiedemann's Annalen, vol. xvi, p. 56, 1882.

† As this work originally appeared in Germany the Daniell (D.) and Siemens Unit (S. E.) were used.

‡ F. Exner, Wien. Ber., lxxx, 1879, und Wied. Ann., x, p. 265, 1880.

§ C. Fromme, Sep.-Abdr. a. d. 20, Ber. d. Oberh. Ges. f. Natur- u. Heilkunde. Wied. Ann., xii, p. 399, 1881.

in from 4 to 6 sec., even after a large deflection. It was so delicate that a single Daniell cell gave a deflection of 170 scale-divisions with the scale 2^m from the mirror and 330,000 S. E. in the circuit.

Inasmuch as resistance coils of the necessary length of wire would have been very expensive, and moreover, as it was interesting to know to what extent one can substitute liquid resistances for wire ones, where a certain degree of accuracy is needed, it was determined to try them in this research. The idea is not at all new and has often been applied; Hittorf* for example used a solution of iodide of cadmium between cadmium terminals; but as far as I know great importance has never been placed upon their accuracy or constancy. Exner† used a solution of $ZnSO_4$ between amalgamated zinc terminals, but one only need read the method in which his resistances were constructed and calculated to see that they can lay no claim whatever to accuracy.

The resistance used in this research was that offered by a column of a solution of $ZnSO_4$ in alcohol, 1^{mm} in diameter in section and 200^{mm} long; this capillary tube was horizontal and each end expanded into a vertical receiver 20^{mm} in diameter and 100^{mm} high, in which stood the amalgamated zinc terminals. A better form however is to simply invert a capillary U-tube into the two receivers as a siphon, since in the other form the precipitate which forms around the terminals falls into the capillary tube, thus reducing its section and increasing the resistance. An alcoholic solution was used because Kohlrausch‡ found that the specific resistance of such solutions was less influenced by slight impurities than in the case of the same salts dissolved in water. Care was taken to prove that the polarization of the terminals could be neglected, which was the case even when a very strong current was used (5 Bunsen cells through 40 S. E.). When afterward this resistance was compared with a wire coil of 200,000 S. E. there could be no difference detected in the results obtained. It moreover remained during the three months of its use constant to within the limits of an error caused by an error of 0·1° C. in the determination of its temperature. Of course the great objection to liquid resistances is their large heat coefficient (from 1·5 to 3·5 per cent for 1·0° C.). However there seems no reason why such resistances should not be used, where they can stand still in a case or water-bath and where about 0·2 to 0·5 per cent is sufficiently accurate. In all cases it is better to determine the resistance experimentally than to calculate it; the above

* W. Hittorf, Wied. Ann., vii, p. 563, 1879.
† F. Exner, Wien. Ber., lxxxiv, p. 528–529, 1881.
‡ F. Kohlrausch, Pogg. Ann. Ergbd., viii, p. 1, 1877.

resistance column was determined from time to time in the Wheatestone's bridge in the ratio 1,000 to 10,000. The resistance can of course be easily varied by varying the dimensions of the capillary tube or the amount of water and salt dissolved in the alcohol.

Objection might be made to the use of the galvanometer for such work, on the ground that the polarization would be diminished by the consumption of the gases by the current through the galvanometer, but a simple calculation will show that it would require a polarization equal to one and a half Daniell's to consume $0{\cdot}1^{cmm}$ of hydrogen per minute working in a circuit whose resistance was 150,000 S. E. That this quantity of gas may be neglected at first when the electrodes are still heavily coated is evident. This theoretical refutation of the above objection was strengthened by the following experiment. Two platinum plates were twice equally strongly polarized, and the first time connected through 150,000 S. E. and left and the curve of the diminution of the polarization plotted; the second time the similar circuit was only closed once a minute and only for from 6 to 8 sec. and then opened again, and the curve plotted in this case. The two curves showed that the consumption of gas by the current when left closed did not make itself apparent until after 17 min., i. e. it may be neglected for the first five minutes at least.

The electromoter possesses the advantage, that with the proper use of a switch or commutator it can be charged to a potential representing that electromotive force of polarization which is active *immediately* after opening the primary or polarizing circuit. It is, however, not as convenient for use, and necessarily has a long time of vibration and is weakly damped; a very convenient form of the switch is that made by Hartman in Würzburg, being a slight improvement upon the Weber quicksilver commutator.

3. On the Rise of the Electromotive Force of the Smee Battery.

Exner* endeavors to explain those values of the electromotive force of the Smee which fall above that calculated, from the thermal equivalents of its chemical reactions, $E=0{\cdot}75\ D$, on the ground that the acid contains oxygen in solution which oxidizes the hydrogen evolved, and thus increases the thermal equivalent of the battery.

This question could be easily answered if it were possible to get and keep a cell entirely free from dissolved gases. Exner used the method of short circuiting the cell for a long time, but

* F. Exner, Wien. Ber., lxxx, 1879 und Wied. Ann., x, p. 265, 1880.

it is evident that this method simply substitutes evolved hydrogen for any other gases which may happen to be dissolved in the acid, and it is just the hydrogen which it is necessary to remove, since to its presence is generally ascribed the diminution of the electromotive force below that obtained with the electrometer or by the compensation method (about 1·5 D).

In this research the following method was used to obtain a cell free from dissolved gases.

A strip of zinc 1×6^{cm} and a platinum wire $0{\cdot}1^{cm}$ in diameter and 5^{cm} long, fastened in the cork of a 100^{cc} flask, constituted the cell used. Its force, when freshly filled with 5 per cent H_2SO_4, through a circuit of 150,000 S. E. was found E=1·07 D. It was then closed in a circuit of only 0·2 S. E. external resistance containing a tangent compass, and its force at the expiration of the first minute determined to E=0·71 D. after 20 min. to E=0·06 D. and after 70 min. to E=0·03 D. These small values, although they agree well with those obtained by Fromme,* can only be considered as approximations owing to the difficulty of accurately determining the internal resistance of inconstant cells. The cell was then left short-circuited for 20 hours in order to let the evolved hydrogen drive out the other gases as completely as possible; at the expiration of this time its force through a circuit of 150,000 S. E. was found quite constant E=0·69 D. In order now to drive out the hydrogen, the flask was placed over a burner and kept at a sharp boil for 20 min., the steam and gas passing off through a long narrow tube in the cork. A layer of petroleum about 1^{cm} deep was poured over the acid while boiling, to assist in keeping gases from redissolving in the acid. The flask was then sealed shut with hard wax and cooled. Its force 5 sec. after being closed in a circuit of 150,000 S. E. was found E=0·86 D. and after 15 sec. to be constant at E=0·70 D. An analysis showed that the liquid in the cell still contained 3 per cent free H_2SO_4. A repetition of the experiment gave the following more marked results.

The same cell was refilled and short-circuited for 18 hours, when its force in a circuit of 150,000 S. E. was found E=0·51 D. during the first minutes, it rose gradually, however, and became constant after six minutes at E=0·70 D. On being boiled and covered with petroleum and sealed as before, its force through 150,000 S. E. was found E=1·01 D., it sank, however, in 4 min. to E=0·88 D. in 25 min. to E=0·83 D., and in $2\frac{1}{2}$ hours to E=0·73 D.

Thus it would seem that the value E=0·70 D. represents that force which is active when the liquid immediately around

* C. Fromme, l. c.

the platinum plate is saturated with hydrogen, and the evolution is just equal to the diffusion of the gas into the liquid.

This experiment would seem to show conclusively that the values above E=0·70 D. are not caused by any oxygen which may be dissolved in the acid.

A similar conclusion was reached in a series of experiments where the other gases were removed by leading CO_2 over the acid for a long time. It however appeared that it would cause a difference of as much as 10 per cent in the force of the cell according as the acid was saturated with air or CO_2, it being larger in the former case. Another series of experiments proved that the force of the Smee could be diminished by saturating the platinum plate with hydrogen without depriving the acid of its dissolved oxygen.*

All the above results are opposed to Exner's theory, that these larger values are due to the oxidation of the evolved hydrogen, and rather support the older theory that they are due to the small force of the hydrogen polarization which acts against the true force of the cell.

4. Experiments on the Fall of the Electromotive Force of the Smee Battery.

When the electromotive force of the Smee is measured in a circuit where the resistance is small in proportion to the size of the cell, i. e. when the density of the current on the platinum plate is large, values are obtained which fall decidedly below that of E=0·75 D.

Exner† says, this is due to the formation of $ZnSO_4$ in the cell which has a larger specific resistance than H_2SO_4, and that zinc is precipitated upon the platinum, thus increasing the internal resistance and diminishing the thermal equivalent of the cell.

To test this question a cell was constructed such that the zinc and platinum were in separate vessels connected by an inverted U-tube filled with 5 per cent H_2SO_4, the ends being tied up with parchment paper. The vessel containing the platinum was furnished with a lid so that CO_2 could be conducted through the vessel or it could be shut up air-tight. Owing to the large internal resistance of such a cell, it was not possible to get a very great density of current on the platinum, still its electromotive force fell as low as E=0·31 D. on being short-circuited, and rose again in a long circuit, even when the vessel containing the platinum was filled with CO_2, as high as E=0·92 D., and finally to E=1·07 D. An analysis proved that the liquid

* Compare also here C. Fromme, l. c.

† F. Exner, Wien. Ber., lxxx, 1879 und Wied. Ann., x, p. 265, 1880.

around the platinum did not contain a trace of $ZnSO_4$. It may be here remarked that had all the H_2SO_4 around the zinc become $ZnSO_4$, the consequent increase in the resistance of the cell, either in this case or that of the flask cell of § 3, it would have made a scarcely perceptible difference in the intensity of the current measured.

These results seem to throw us back upon the old explanation, which ascribes the variations in the electromotive force of the Smee battery, to the variations in the counteracting force of the hydrogen polarization of the platinum plate.

5. Determination of the Electromotive Force of Polarization.

The maximum value of this force can be arrived at in two ways, either by measuring it while the primary current is closed, or by plotting the curve of the fall of the force after opening the primary current, and from it deducing by exterpolation, the value for the instant of opening.

Exner* and Beetz† assume that the value obtained immediately after opening the primary current is practically this maximum value. Fromme,‡ on the contrary, says, "if one wishes to obtain the true maximum value, it is absolutely necessary to measure the polarization while the primary current is still closed." I must admit, from my experience, that values could only then be considered as approximating the maximum when they were determined *immediately* after opening the primary current, which it is scarcely possible to accomplish, unless perhaps with an electrometer and switch as before mentioned.

An example will show how rapidly the polarization vanishes. The following is the falling off of the polarization of 5 per cent H_2SO_4 between electrodes of gas-retort carbon.

Time in sec.,	0	2	10	20	30	45	60	120	180	480
Force in Daniell,	1·92	1·77	1·63	1·54	1·49	1·43	1·39	1·28	1·20	1·00

The value for "0" sec. is that calculated by closed primary current.§

Inasmuch as a galvanometer was used for the following determinations the method by closed primary current seemed decidedly preferable and was employed. Two difficulties however, arise when this method is applied. In the first place a

* F. Exner, Wien. Ber., lxxviii, 1878 und Wied. Ann., v, p. 388, 1878.

† W. Beetz, Wied. Ann., x, p. 348, 1880, u. Münch. Ber, p. 429, May, 1880.

‡ C. Fromme, Sep. Abdr. a. d. 20, Ber. der Oberh. Gesellsch. f. Natur. u. Heilk., u. Wied. Ann., xii, p. 399, 1881.

§ The vanishing of polarization has also been studied by Beetz and Witkowski, among others, whose results agree with mine; compare here W. Beetz (Pogg. Ann., lxxix, p. 106, 1850) and A. Witkowski (Wied. Ann., xi, p. 759, 1880.)

branch of the primary current goes to strengthen the current from the polarized voltameter through the galvanometer; in the second place a branch of the secondary current (from the polarized voltameter) goes backward through the primary circuit. That these two currents are weak enough to be neglected only under peculiar and rarely fulfilled conditions is evident as soon as we calculate their strength from the given forces and resistances. Call E the electromotive force of the polarizing (primary) battery and γ the resistance in the primary circuit exclusive of that in the voltameter which we will call w, let W be the resistance in the circuit of the galvanometer (150,000 S. E. or 330,000 S. E.); let further i be the intensity of current in the galvanometer, i' that in γ and i'' that in w and I, that when E is closed through $(\gamma+\mathrm{W})$ alone, i. e. $\mathrm{I}=\frac{\mathrm{E}}{(\gamma+\mathrm{W})}$. If now we call the force of polarization P, we have according to Ohm's laws

$$i=i'-i''; \quad \mathrm{E}=i'\gamma+i\mathrm{W}; \quad \mathrm{P}=-i''w+i\mathrm{W},$$

whence we obtain by substitution and transformation,

$$\mathrm{P}=\frac{\mathrm{W}+\gamma}{\gamma}.w.i-\mathrm{E}\frac{w}{\gamma}+i\mathrm{W} \text{ or } \mathrm{P}=(i-\mathrm{I})\frac{\mathrm{W}+\gamma}{\gamma}w+i\mathrm{W}.$$

If in this last equation we neglect $\gamma=100$ at the most, as added to $\mathrm{W}=330{,}000$, we have

$$\mathrm{P}=\mathrm{W}\left[i-\frac{w}{\gamma}(i-\mathrm{I})\right]. \qquad (1)$$

From (1) we see that only when $\frac{w}{\gamma}=0$ can we put $\mathrm{P}=\mathrm{W}.i$, which is very seldom the case, for γ rarely exceeds 5 or 6 S. E. and w varies between 0·3 and 5·0 S. E. I increased the resistance γ to 100 S. E. in order to make $\frac{w}{\gamma}$ smaller and more accurately determinable. All the values of polarization given below were calculated with formula (1).

Inasmuch as these experiments on polarization were undertaken with a view to testing whether we can *a priori* calculate the electromotive force of polarization from the thermal equivalent of the chemical reactions which take place thereby, some side experiments, more or less directly allied to this question, were made. For example, Exner* wishes to approximate the thermal equivalent of the compound $PtCl_4$ out of the difference in the polarization of HCl between platinum and between graphite electrodes, 1·26 D. and 1·60 D.; upon the supposition that all the evolved chlorine in the one case dissolved off platinum to $PtCl_4$. To prove the incorrectness of this supposition

* F. Exner, Wien. Ber., lxxviii, 1878, und Wied. Ann., vi, p. 353, 1879.

chlorine was evolved by a weak current upon a platinum plate until it should have dissolved off 0·176 grm. of platinum, the actual loss in weight of the plate was 0·00007 grm., i. e. there was none dissolved off at all. F. Kohlrausch had already obtained the same result in a similar experiment. In fact it is very difficult to explain the differences which almost always exist between the polarization of the same solution between platinum and between carbon electrodes, if we consider the electrodes as mere conductors, as Exner does, and do not admit that they become electrically excited.

Another experiment was made in which a current was found and measured between one platinum plate saturated with hydrogen and another free from all gases except CO_2, where the force was E=0·68 D. at first, but gradually fell off. There is no apparent thermo-chemical equivalent for this current and the only visible cause for it is the transfer of the hydrogen from the more to the less saturated plate. Beetz* has also shown the electromotive force of polarization between two platinum plates, when one is surrounded with hydrogen, even when the acid had been pumped and boiled out in the most careful manner possible.†

6. Values of the Electromotive Force of Polarization.

The results here obtained are arranged in the tables on the following pages.

In table I, the first column, "electrolyte," gives the solution employed; and the second, "per cent," the percentage of the salt in the solution. Under carbon and platinum are given the values of the polarization; "P," between "gas retort carbon," and bright platinum electrodes (simple surface 8^{sqcm}), where Δ gives the density‡ of the current upon the electrode, 1^{sqmm} taken as a unit, Δ is calculated from the formula $\Delta=\frac{E-P}{(w+\gamma).S'}$, where the letters have the same meaning as in formula (1) and S is the surface of the electrode, 800^{sqmm}. The values of "P," the polarization, are, in the cases where the primary current was closed, calculated by formula (1); these values are given under "3 Buns. closed" and "2 Buns. closed," the primary current being furnished by two or three Bunsen cells respectively. Under "open" are given the values determined after opening the primary current, the length of time elapsing until the read-

* W. Beetz, Wied. Ann., x, p. 348, 1880, u. Münch. Ber., p. 429, May, 1880.

† Compare here H. Helmholtz, Ber. Berl., p. 288, 1880; F. A. Flemming, Phil. Mag. V, i, p. 142, 1876; and Helmholtz and Root's, Pogg. Ann., clix, p. 416, 1876.

‡ I unfortunately followed previous examples and kept the electromotive force of the primary circuit constant; whereas it is evident that the only way to obtain results comparable with each other is to keep the density of current on the electrodes constant.

TABLE I.

Electrolyte.	%	Gas Retort Carbon.						Platinum.				Exner.		Newly Calc.
		3 Buns. closed.		2 Buns. closed.		Open.		2 Buns. closed.		Open.				
		Δ	P	Δ	P	Sec.	P	Δ	P	Sec.	P	Obs.	Calc.	
		0·000		0·000				0·000						
H_2SO_4	5	43	2·02	20	1·92	2	1·76	29	1·95	5	1·67	1·42	1·43	1·36
HCl	6	--	----	26	1·54	2	1·45	44	1·33	5	1·16	1·60	1·61	1·57
NaCl	6	38	2·37	16	2·17	2	2·05	28	1·97	6	1·78	2·08	2·06	2·12
NaOH	5	43	1·93	22	1·79	4	1·63	--	----	--	----	----	----	1·36
$NaNO_3$	5	39	2·24	16	2·12	3	1·99	23	2·18	5	1·30	----	----	1·91‡
NaI	5	50	1·48	27	1·43	3	1·36	44	1·24	5	0·97	1·25	1·24	1·07
$Cu(NO_3)_2$	5	54	1·20	31	1·16	1	1·04	40	1·45	6	1·29	1·11	1·09	1·04‡
$CuSO_4$	5	53	1·20	30	1·18	4	1·06	41	1·34	5	0·88	1·13	1·15	1·12
$ZnCl_2$	10	44	1·92	20	1·89	2	1·84	31	1·86	8	1·82	----	----	2·25
$ZnSO_4$	9·8	41	2·07	18	1·99	2	1·90	21	2·26	4	1·88	2·14	2·14	2·12
$MnCl_2$	5	42	2·02*	20	1·91	--	----	30	1·91†	5	1·60	----	----	2·55‡
$MgSO_4$	5	37	2·32	19	1·91	3	1·68	18	2·39	3	1·62	----	----	2·00‡
$AgNO_3$	25	62	0·78	38	0·75	2	0·69	57	0·75	6	0·68	0·42	0·34	0·34‡
$Pb(NO_3)_2$	5	49	1.49	26	1·47	3	1·38	39	1·45	3	1·26†	----	----	1·36‡

* Sank in 20 min. to P=1·88.

† The anode became covered with a brown film.

‡ Values uncertain because one does not know the secondary reactions.

TABLE II.

Substance of the Electrode.	Simple Surface. sq. cm.	H_2SO_4 5%.				HCl 6%.				NaCl 6%.			
		2 Buns. closed.		Open.		2 Buns. closed.		Open.		2 Buns. closed.		Open.	
		Δ	P	Sec.	P	Δ	P	Sec.	P	Δ	P	Sec.	P
		0·000				0·000				0·000			
Platinised platinum	28·6	--	--	6	1·57	09	1·13	5	1·12	06	1·80	2	1·77
Bright platinum	5·3	29	1·95	5	1·67	44	1·33	5	1·16	28	1·97	6	1·78
Gas retort carbon, used	28·0	--	--	5	1·53	--	--	10	1·38	--	--	5	2·05
Electric lamp points, used	2·0	--	--	5	1·48	--	--	7	1·45	--	--	10	2·02
		0·00	--	--	--	0·00	--	--	--	0·00	--	--	
Lead-pencil graphite	1·1	117	2·14	2	1·85	158	1·78	4	1·52	109	2·17	2	1·98
		0·000	--	--	--	0·000	--	--	--	0·000	--	--	--
Retort carbon, old	2·3	67	1·93	4	1·62	84	1·63	4	1·43	--	--	4	1·70
Retort carbon, new, as furnished	8·0	20	1·94	4	1·59	--	--	--	--	--	--	--	--
Retort carbon, new, boiled in HCl	8·0	22	1·81	3	1·52	--	--	--	--	--	--	--	--
Retort carbon, new, boiled in H_2SO_4	8·0	20	1·92	2	1·76	26	1·54	2	1·45	16	2·17	2	2·05

TABLE III.

Electromotive force of the polarizing battery	=1·00 D.	1·72 D.	3·44 D.	5·16 D.	6·88 D.
Density of current in the voltameter (mm, mg, sq. mm.)	=	0·00006	0·00037	0·00073	0·00112
For 5 per cent H_2SO_4 between platinum electrodes	P=	1·46 D.	1·95 D.	2·01 D.	2·07 D.
Density of current in the voltameter (mm, mg, sq. mm.)	=0·000002	0·00006	0·00019	0·00043	0·00067
For 6 per cent NaCl between carbon electrodes	P=0·99 D	1·34 D.	2·17 D.	2·37 D.	2·49 D.

ing from which P was calculated being given under "sec." in seconds. I would here remark, that owing to the difference of rapidity with which the polarization vanishes for different combinations, the quickest time at which it was possible to read off the position of the needle, after opening the primary current, varied from 1 to 5 seconds. In columns 13 and 14 are the values observed and calculated by Exner, and the last column contains the values newly calculated from the thermo-chemical equivalents of J. Thomsen,* which are given in convenient form in a table in the last edition of Richter's Anorganische Chemie. The calculations were made according to the scheme given in Table IV.

TABLE IV.

Daniell.	$ZnSO_4 - CuSO_4$		
	248·4 − 198·3 =	50·1	1·00 D.
H_2SO_4	$H_2SO_4 + H_2O - H_2SO_4$		
	210·7 + 68·3 − 210·7 =	68·3	1·36 D.
HCl	HCl		
	39·3 =	39·3	1·57 D.
NaCl	$NaCl + H_2O - NaOH$		
	96·5 + 68·3 − 111·8 =	53·0	2·12 D.
NaOH	$2NaOH + H_2O - 2NaOH$		
	223·6 + 68·3 − 223·6 =	68·3	1·36 D.
$NaNO_3$‡	$2NaNO_3 + 3H_2O - 2HNO_3 - 2NaOH$		
	212 + 204·9 − 98·2 − 223·6 =	95·5	1·91 D.
NaI	$NaI + H_2O - NaOH$		
	70·3 + 68·3 − 111·8 =	26·8	1·07 D.
$Cu(NO_3)_2$‡	$Cu(NO_3)_2 + H_2O - 2HNO_3$		
	82·2 + 68·3 − 98·2 =	52·3	1·04 D.
$CuSO_4$	$CuSO_4 + H_2O - H_2SO_4$		
	198·3 + 68·3 − 210·7 =	55·9	1·12 D.
$ZnCl_2$	$ZnCl_2$		
	112·8 =	112·8	2·25 D.
$ZnSO_4$	$ZnSO_4 + H_2O - H_2SO_4$		
	248·4 + 68·4 − 270·7 =	106·0	2·12 D.
$MnCl_2$‡	$MnCl_2$		
	128·0 =	128·0	2·55 D.
$MgSO_4$‡	$MgSO_4 + 3H_2O - H_2SO_4 - Mg(OH)_2$ (dry)		
	323·0 + 204·9 − 210·7 − 217·2	100·0	2·00 D.
$AgNO_3$‡	$2AgNO_3 + H_2O - 2HNO_3$		
	46·6 + 68·3 − 98·2 =	8·4	0·34 D.
$Pb(NO_3)_2$	$Pb(NO_3)_2 + H_2O - 2HNO_3$		
	97 9 + 68·3 − 98·2 =	68·0	1·36 D.

Values marked with a (‡) in tables I and IV are uncertain because we do not know what secondary reactions take place, nor do we know, if and to what extent the secondary reactions† affect the polarization. Table II contains the polarization of 5 per cent H_2SO_4, 6 per cent HCl and 6 per cent NaCl, between the electrodes named in the first column; other-

* J. Thomsen, Kolbe's Journ., xi, p. 18 and xii, 1875.

† Compare here, Wiedemann Galvanismus, ii (2), p. 498, § 1130–1146, 1874, on the effect of primary and secondary reactions in voltameters.

wise the abbreviations are to be understood as in Table I. Table III gives the polarization as it increases with the increase of the force of the primary battery from E=1·00 D. to E=4 Bunsen=6·88 D. and will be understood without further explanation. In all cases the force of the Daniell battery was taken as the unit of electromotive force.

7. Conclusions.

Although, as is well-known, the force of polarization in general varies according to the chemical affinities of the elements or radicals separated, still we cannot, yet at least, calculate the electromotive force of polarization from the thermal equivalents of the reactions, because we do not know which of the reactions, primary or secondary, should be taken account of, nor do we know their thermal equivalents. Table I seems to establish what has just been said; in most cases the calculated value is much smaller than the observed one, and the latter is not a true maximum value, but only the largest attainable with two or three Bunsens respectively, in the polarizing circuit. Especially in the case of H_2SO_4 is the difference great, and in fact, if its polarization were only P=1·36 D., as calculated one ought to get a good evolution of gas with two Daniell cells, which, on the contrary were only able to evolve 5^{ccm} in 17 hours instead of the 300^{ccm} which they could have produced had the polarization been only P=1·36 D.

Tables I and II confirm the earlier experiments, showing that the polarization is not independent of the substance of the electrode, even when the latter remains chemically unaffected.

Exner* published a series of experiments to prove that the electromotive force of polarization keeps equal to that of the primary battery, when the latter is increased from zero upward, until it reaches the point where the evolution of gas becomes visible, and that from this point it (the polarization) remains constant, no matter how much we increase the force of the primary battery. This result is contradicted by those given in Tables I and III, inasmuch as with two Bunsens =3·4 D., the evolution of gas was very easily visible.† Exner's results are in so far in harmony with the theory of the conservation of energy as that no one will contend that a weaker electromotive force can overcome a stronger; but Helmholtz‡ has shown for

* F. Exner, Wied. Ann., v, p. 388, 1878.

† The results given in Tables I and III only confirm the previous ideas regarding the dependence of the polarization upon the density of the current upon the surface of the electrode.

‡ Helmholtz, Pogg. Ann., cl. p. 483, 1873; compare also F. A. Flemming, Phil. Mag. V, i. p. 142, 1876; A. Bartoli, Nuovo Cim. III, iv, p. 92. 1878, III, v, p. 203, 1879.

platinum, and from results here obtained it would seem to be true for at least carbon also, that an electromotive force which is theoretically too weak to decompose the solution between the platinum electrodes still does generate a current through a voltameter, which was originally free from all dissolved gases, and polarizes the electrodes, assisted by the occlusion of the evolved gases by the platinum.

It is difficult to explain according to the "chemical theory" why, on closing the primary circuit, the polarization does not immediately reach its maximum value instead of doing so gradually, as is the case. According to the "contact theory" the polarization of H_2SO_4 between platinum electrodes, on closing the primary current, increases gradually until we have a platinum kathode saturated with hydrogen opposed to the anode saturated with oxygen, just as in the polarization of $ZnSO_4$ it increases until we have the kathode covered with zinc, opposed to the Pt | O anode, in other words, until our voltameter has become a Smee cell.

That solutions of HCl and NaCl between the same electrodes give different values of the electromotive force of polarization, Exner considers as an argument against the contact theory, because we have the same gases acting upon the same electrodes. The reason, however, is evident. In the one case the series acting is

$$\text{Pt} \mid \text{H}+\text{H} \mid \text{HCl}+\text{HCl} \mid \text{Cl}+\text{Cl} \mid \text{Pt}. \qquad (1)$$

and in the other case

$$\text{Pt} \mid \text{H}+\text{H} \mid \text{NaOH}+\text{NaOH} \mid \text{NaCl}+\text{NaCl} \mid \text{Cl}+\text{Cl} \mid \text{Pt}. \qquad (2)$$

That these two series should not give the same electromotive force is what one would expect.* A test experiment, however, gave the following equation,

$$\text{Pt} \mid \text{NaOH}+\text{NaOH} \mid \text{NaCl}+\text{NaCl} \mid \text{Pt}=0{\cdot}39 \text{ D}.$$

and furthermore it gave no difference in the polarization when the kathode as well as the anode was surrounded with NaCl solution, and when the vessel containing the kathode was filled with NaOH solution, thus showing that series (2) really represents the forces acting in the polarization of NaCl solution between platinum electrodes.

The secondary reactions in some cases must be very peculiar; for example in the electrolysis of a solution of $MnCl_2$ there was no chlorine gas evolved, and the anode became covered with a brownish-red film insoluble in H_2O, H_2SO_4 or dilute HCl, but concentrated HCl dissolved it off to a reddish-brown solution which gave off quantities of free chlorine. The chlorine had

* Aryton and Perry, Trans. Roy. Soc., i. p. 34, 1880; Helmholtz, Wied. Ann., iii, p. 201, 1878; F. Moser, ibid., p. 216; and E. Kittler, Wied. Ann., xii, p. 577, 1881.

apparently simply added itself to the $MnCl_2$, thus forming a higher chloride of manganese.

Adolfo Bartoli* in an interesting research on polarization proceeds as follows. A very strong battery (400 zinc-carbon cells) is closed a very short time (0·004 sec.) through the voltameter, and the polarization calculated from the first elongation of the galvanometer needle, as a function of the amount of transmitted electricity. All the connections were made and broken automatically. He finds for the following combinations the following maximum values.

Platinum electrodes and

H_2O	HCl	HBr	HI
2·00 D.	1·30 D.	0·94 D.	0·58 D.

The values calculated from the thermal equivalents are

1·36 D.	1·57 D.	1·13 D.	0·52 D.

These values of Bartoli's agree with those given in Table I, but not at all with the calculated ones, so that we cannot calculate the polarization from the thermo-chemical equivalents, even under these circumstances.

Conclusion.

The result of this research may be summarized in the four following propositions. 1. The generally accepted explanation of the variations of the force of the Smee battery, which ascribes them to the variations of the hydrogen polarization of the platinum plate, must still be looked upon as correct. 2. The electromotive force of polarization is by no means independent of the substance of the electrodes. 3. We can not calculate the polarization from the thermo-chemical equivalents. 4. The electromotive force of polarization can be raised considerably above that necessary to produce a visible evolution of gas and the former results upon this question are confirmed.†

* Adolfo Bartoli, Il Nuovo Cim. III, vii, p. 234, 1880.

† Compare Wied. Galv., i, p. 681, 1874.

ART. XXX.—*The Age of the Southern Appalachians;* by JNO. B. ELLIOTT, M.D., Professor Chemistry, University of the South, Sewanee, Tenn.

THE following paper is the result of several geological excursions made during the past five years in the mountain regions of Tennessee, Georgia and the Carolinas. They were directed along the lines mapped out by Tuomey, Safford, Bradley and Kerr; and were undertaken with the desire of obtaining by personal observation sufficient data for an opinion concerning the geological age of this debatable region.

The relative positions of the geological sections made during these excursions need explanation. If a line be drawn from Cleveland, Tennessee, southeastward to Atlanta, Georgia, and from Atlanta, Ga., northeastward to Spartanburg, S. C., a triangular area will be outlined within which lie the plateau-land of northeast Georgia and a portion of the same plateau region in Tennessee and N. Carolina. Beginning at the point where the Hiwassee River breaks through the Smoky Mountains east of Cleveland, Tenn., this range can be traced far southward into Georgia. Frog Mountain in Tennessee and the Cohuttas and Fort Mountain in Georgia are the last lofty peaks of the great chain. Towards the south the prolongation of Fort Mountain fades away into the Coosawattee Hills to rise again further south into the prominent peak of Sharp Mountain. Still southward of Sharp Mountain an imposing mass of lofty hills, between Cartersville and Allatoona, form the last conspicuous landmarks of the range.

Beginning again at Cæsar's Head, S. C., where the Blue Ridge enters the eastern extremity of our triangular area, this chain of mountains leads us southwestward into Georgia. In the first portion of its course the mountain range trends westward forming the boundary line between the Carolinas. It then enters northeastern Georgia, forming the boundary line between Rabun and Townes Counties, from which point it traverses Georgia in a southwesterly direction to Jasper, in Pickens County, Ga. Along this latter portion of its course it forms the center of the water-shed between the streams that flow northwestwardly into the Oostanaula River and those that flow southeastwardly into the Etowah. Beyond Jasper the chain fades away into the hills which represent the southern extension of the Smoky Mountains. The Smoky Mountains and the Blue Ridge thus run together in Georgia and offer short sections near and at their point of coalescence along which much can be learned that will throw light upon the relations of these ranges in their more widely separated portions.

The first of these sections was made in the summer of 1878. This section extended from Cleveland, Tennessee, up the Ocoee River to Ducktown; from Ducktown eastward to Murphy, N. C., and from Murphy westward down the Hiwassee River back to Cleveland.

The second section was made in the summer of 1879. It extended from Greenville, S. C., to Saluda Gap; from Saluda Gap to Cæsar's Head and Table Rock, and from Cæsar's Head to Hendersonville, N. C.

The third section was made in the summer of 1880 and extended from Cartersville, Georgia, to Acworth, Ga.

The fourth section was made during the past summer (1882), and extended from Dalton, Georgia, eastward across the Smoky Mountains to Elijay, Georgia; from Elijay still eastward across the Blue Ridge to Armacolola, Ga.; from the latter place westward again to Jasper and from Jasper to Dalton.

By glancing at a good map of this region it will be seen that the first section crosses the Smoky Mountains at the western extremity of the triangular area spoken of. The second section crosses the Blue Ridge at the eastern extremity; the third section crosses the southward extension of the two ranges after their coalescence; while the fourth section crosses at an intermediate point where the two mountain chains are about twenty-five miles apart. This latter was planned with the design of utilizing in as short and complete a section as could be obtained the lithological experience gained in the other three.

Section I. From Cleveland, Tenn., to Ducktown, Tenn., and Murphy, N. C.

This section was made to study the characteristic features of the Knox, Chilhowee and Ocoee formations as described by Professor Safford. It will be given very briefly as it has been

Lower Silurian	Canadian	Chazy	Maclurea Limestone.
		Quebec	Knox Dolomite.
			Knox Shale.
		Calciferous	Knox Sandstone.
	Primordial	Potsdam	Chilhowee Sandstone.
		Acadian	Ocoee Conglomerate and Slates.
Archæan			//////////////////////////////////

already made known through Professor Safford's report and Professor Bradley's article on this region. It is considered of

importance here because some conclusions drawn by Professor Bradley are regarded as founded in error, and the conclusions bear with force upon the question of the supposed age of the formations about Ducktown. The equivalents of the Tennessee formations are given for the convenience of the reader.

Nothing can be added to the description given by Professor Safford of the formations occurring in this section to Ducktown. From Cleveland to the mouth of the Ocoee gorge the regular succession of the beds of the Knox Group were crossed. But few outcrops of the sandstone could be identified. (A still more marked absence of the sandstone is noticed in the 4th section made south of this in Georgia.) After passing over the Knox and by the outcrop of the Chilhowee forming Starr's Mountain, the Ocoee conglomerate is met about a half mile beyond Parke's mill. The conglomerate is composed of pebbles of quartz and feldspar, varying in size from that of a small bullet to a pigeon's egg. The rock is massive. The slates vary from a dark blue-black and dense, to grayish and greenish and less dense forms. The conglomerate and slates are conformable. The dip is S.E. at high angles. The formation, where the dark slates occur nearest the western outlet of the gorge, gives rise to massive mountains. For the first five miles the conglomerate is much the most abundant. For the succeeding seven miles the slate largely predominates, containing here and there layers of conglomerate. In the twelve miles passed over, the conglomerate undergoes a gradual metamorphism, and when it reappears again at the end of this distance it has become a fine grained gneiss in which all distinction of pebble forms has disappeared. Within three miles of Ducktown shales set in, now become a hydromica schist. Up to Ducktown the strata have a S.E. dip at high angles, in some places vertical. After passing Ducktown over Wolf Mountain gap, the gneiss sets in again with N.W. dips showing that a synclinal had been passed near Ducktown. The gneiss here is lighter colored and less massive than the gneiss of the Smoky Mountains. As will be seen in the fourth section this synclinal near Ducktown appears to coincide with one crossed near Mountaintown, Georgia. Wolf Mountain (a low ridge) is made up of this gneiss with over and underlying semi-metamorphic shales. Beyond Wolf Mountain, to the east, Franklin Mountain was crossed composed of the same gneiss with N.W. dips. Still farther east, at Rice's, about six miles in an air line from Ducktown an anticlinal was passed and the dip changed to S.E. The beds forming this anticlinal were composed of alternating layers of hydromica schists and gneiss. Two miles east of Rice's the hydromica schists were found containing staurolite and garnets; dip still S.E. at high angles.

These dips do not change until the marble beds of the Knox dolomite, mentioned by Professor Bradley, are reached at Murphy, N. C. Professor Bradley's description of these beds were verified in every particular. Upon the return trip down the Hiwassee S.E. dips continued until Davidson's was reached near Grape-vine Creek. Here the anticlinal is crossed which was crossed on the other route at Rice's, east of Ducktown. It occurs, as Professor Bradley states, in hydromica schists and gneisses, just as it was found to occur at Rice's. From this point N.W. dips set in and continue to Hammonds (abreast of, but N.E. of Hennegars), where a synclinal is crossed bringing in the S.E. dips that continue beyond the State line.

This section has been run over thus briefly because of the full description already given. It was undertaken, as has been mentioned, to study the formations and to confirm Professor Bradley's section. It is inserted here because Professor Bradley refers the Ducktown mines to the anticlinal at Davidson's, whereas the Davidson anticlinal was found to pass six miles east of Ducktown to Rice's. Ducktown is in a synclinal that corresponds with the synclinal at Henegar's. This is an important point, for a later section in Georgia south of and parallel to this crosses a synclinal and then an anticlinal before reaching the marble beds of Elijay, and leads to the belief that the hydromica schists and the less massive and light colored gneisses, at and east of Ducktown, belong to the Knox group. This would place the hydromica schists and gneisses in the anticlinal at Davidson's and Rice's not below the Ocoee but above it in the Knox. In the four lines along which these formations have been crossed west of the Blue Ridge, a recurrence of the typical Ocoee conglomerate with its dense blue black slates, as shown along the line of the Great Smoky Mountains, has nowhere been seen.

Section II. From Greenville, S. C., to Cæsar's Head and Hendersonville, N. C.

The object of this section was to verify the section of Cæsar's Head and Table Rock, given by Professor Tuomey in his report upon the geology of South Carolina in 1848, p. 73.

The following is a copy of Professor Tuomey's section:

A. Table Rock. B. Caesar's Head. 1. Hornblende Slates. 2. Gneiss. 3. Hornblende Slates.

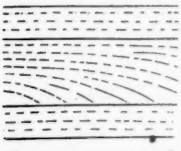
The importance of the unconformability reported by Professor Tuomey can at once be seen. If the great strata of gneiss, forming the Head and Table Rock, are unconforma-

ble to the underlying hornblende slates, there is afforded a starting point for the classification of the rocks of the Blue Ridge. The existence of such a line of division becomes a factor of fundamental importance in the determination of the age of these metamorphosed strata. Not only does Professor Tuomey assert unconformability, but he represents in his section the existence of an anticlinal axis of which Cæsar's Head and Table Rock are the eastern and western declivities. He furthermore teaches that the great gneiss bed was deposited over a preëxisting anticlinal in the underlying hornblende slates, and that a subsequent upheaval along the same anticlinal axis produced anew an anticlinal in the gneiss-bed.

The road from Greenville to Cæsar's Head passes over a not very hilly country. The formations passed over are in a state of almost complete decomposition, but here and there along the road the stratification could be plainly seen. The formations noticed were a black, hornblendic slate, decomposed to some distance beneath the surface, giving rise to red clay hills and very red colored roads, and here and there a lighter colored very friable siliceous gneiss, giving rise to light colored and sandy roads. From observations subsequently made (see sections 3d and 4th), these formations are regarded as the metamorphosed equivalents of the Knox sandstone and shale.

As the road ascends the Saluda range to the Head it gradually traverses the entire thickness of the great gneiss bed that forms the chain. The gneiss appeared in heavy massive beds, with dip N.E. 15°. Here and there layers of hornblende slates were noticed mingled with the gneiss. The slates, though more irregular and broken and varying locally in dip, did not at any point show general unconformability. The gneiss cap at Cæsar's Head was found to be of great thickness. At the point of the Head several hundred feet of it are exposed in a vertical precipice, the mass being composed of heavy layers of the gneiss lying one upon the other, with dip N.E. about 15°. The rock itself is a very dense quartzitic gneiss, and is almost identical with the typical quartzitic gneiss of the Ocoee as found at Gregory's. (Sec. 4th).

In order to test the question of existing uncomformability, a section was begun at the foot of the western exposure of the precipice, and was run down a ravine to the Saluda river at the base of the mountain. A short distance down this ravine a partial exposure of hornblende slate was seen. In this exposure local flexure was noticed, (see fig.) but the beds of gneiss above and below the slate were conformable with one another, and had the dip of the cap rock above. The gneiss was more siliceous and



friable than the summit mass. The ravine was followed down through the "dismal" for a mile and a half to its junction with the Saluda river. The gneiss beds continued to show the same dip as the summit rock down the entire ravine. Here and there layers of hornblende slates alternated with the gneiss, but were always conformable. The section was continued up the Saluda river to the falls. The hornblende slate was also met with along this section, but it was always found conformable with the gneiss with which it was bedded.

The following day a trip was made on foot across from Cæsar's Head to Table Rock. The distance is ten miles. On this trip another section of Cæsar's Head was obtained, but no unconformability could be discovered, save such as could be easily accounted for by local disturbance. Table Rock was approached from the N.E., and the ascent was made up the wooded slopes to the base of the enormous mass that forms the Table. No good exposure of the strata could be obtained on the ascent, as it was made up a "ridge." When the base of the Table was reached the mass was seen to disappear beneath the soil without change of bedding or dip. The dip was the same as the mass at Cæsar's Head, N. E. about 15°, and the rock identical in nature, a quartzitic gneiss. The base of the rock was examined along its northern flank, as along this face the mass is exposed to a lower level than on any other side. Upon this northern flank there is a precipitous exposure of the Table for nearly a mile, with an almost vertical precipice of about 800 feet. The mass was composed, as at Cæsar's Head, of superimposed beds of the gneiss. About forty feet above the base of the precipice a layer of contorted hornblende slates is included among the beds of gneiss. This layer is about eight feet thick and so contorted as to be in some places completely reflexed upon itself. Nevertheless, it was perfectly evident that the contorted layer was of the same age and formation as the enclosing gneiss. If this layer had been seen with the immediately over- and underlying beds hidden from sight, uncomformability would have been suggested. This explained the local contortions in the slates noticed in ascending the Saluda range and in the section of Cæsar's Head. Near the middle point of the northern exposure of the Table Rock, where the rock is exposed to its lowest point, a precipitous ravine descends to the valley below. The bed of this ravine was made up of a series of precipitous ledges, down which a complete section of the mountain mass could be obtained. Down this ravine each successive ledge of rock was examined. The ledges were composed of the same gneiss encountered in the section at Cæsar's Head. Here and there layers of hornblende slates were likewise found, but they were conformable with

the enclosing beds of gneiss, while the gneiss had the same dip as the overlying mass composing the Table. The ravine gave a complete section to within two hundred and fifty feet of the valley level. The elevation of the summit above the valley is about 2,300 feet.

The conclusion was unavoidable that Table Rock was but an outlier of Cæsar's Head, composed of the same gneiss and hornblende slates, having the same N.E. dips with all of the beds conformable from summit to base. This revelation was a great disappointment, as the section had been made simply to verify the work of Professor Tuomey, with the hope that it would afford a key to the problem of the age of these mountains. From the absence of all Archæan characteristics, there was no warrant for referring the gneiss to any formation older than the Ocoee. This hypothesis, however, needed the subsequent sections made in Georgia to warrant its presentation here. (See sec. 4th, and conclusion).

The topographical peculiarity of the Blue Ridge is a matter to be noticed, as it aids somewhat in explaining conclusions drawn when the mountain range had been studied at other points. Wherever the Blue Ridge is ascended from the S.E. the ascent is long and the elevation attained is great. When, however, the eye is directed from the elevation to the northwest, the observer realizes that he has ascended the southeastern slope of a great plateau. The mountain masses to the northwest appear to rise from the level upon which the observer stands. This was noticed by Professor Tuomey at Saluda Gap. It is very noticeable at Cæsar's Head. It is still more marked where observed near Burnt Mountain Gap, Georgia. Wherever streams flow down this southeastern edge waterfalls of great height and beauty exhibit themselves. The falls at Plumley Mountain, near Saluda Gap, the falls near Cæsar's Head, and those at Armacolola, Georgia, are all caused by streams precipitating themselves over the great monoclinal of the Blue Ridge. This unity of form is a connecting link in the question of identity of age.

The road from Cæsar's Head to Hendersonville is approximately parallel with the trend of the Blue Ridge, although several miles to the west of it. As the trip was made in a regular stage containing other passengers, nothing more than a superficial examination of the formation passed over could be made. The important point noticed and observed at one or two places was the conformability of the gneiss and hornblende slates. Nine miles from Cæsar's Head a new formation was first observed. It was a dove-colored fine-grained hornblende gneiss containing large feldspar crystals. The feldspar had more the appearance of pebbles than of crystals. It could be easily mistaken for a partially metamorphosed quartz con-

glomerate unless the pebbles are broken and examined. This formation at eleven miles from Cæsar's Head had a low S.E. dip. Time did not permit the tracing of this formation towards the Blue Ridge, but from the dip of the gneiss bed at Cæsar's Head the most plausible conjecture seemed to be that the dove-colored gneiss was above the former and therefore younger. This conjecture is strongly supported by the facts revealed in Sec. 4.

SECTION III.—FROM CARTERSVILLE TO ACWORTH, GEORGIA.

This is a short section along the W. & Atlantic railroad. To understand the relations of the formations passed over, it must be explained that the Knox Group of Professor Safford sweeps southward from Tennessee into Georgia. As it enters Georgia the trend of the formation is almost due south. The formation retains in Georgia the characteristic topography that marks it in Tennessee. The dolomite gives low cherty ridges; the shale, wide valleys. As will be seen in section 4th, when the Knox Group was traversed from Dalton to the Smoky Mountains, the dolomite was readily recognized, while the characteristic limestone of the shale assumed a more shaly structure than usual. The rare appearance of the typical sandstone was accounted for by the supposition that the sandstone had likewise passed into a more shaly condition resulting in some ridges composed of shale sufficiently siliceous to render it enduring. All of the country between the W. & Atlantic railroad and the Smoky Mountains is composed of this group with one or two outcrops of Trenton limestone. From Dalton the W. & Atlantic railroad runs south approximately parallel with the strike of this formation. As the railroad turns southeast from Kingston it begins to traverse the group. Just beyond Cartersville the road enters upon metamorphic strata. The section was undertaken to examine these latter.

As before mentioned, the lofty hills lying between Cartersville and Acworth are the last conspicuous elevations arising along the southern extension of the Smoky Mountains. As the topography of the Lower Silurian formations in Georgia is almost as characteristic as their rock structure the supposition was that the Ocoee formation would be found where the railroad passed through these hills. The section was made on foot along the railroad.

A half mile south of Cartersville a low rounded hill is skirted by the railroad. Upon its sides and summit a coarse breccia was found corresponding in superficial appearance with a similar mass seen in the Knox Group near the western extremity of Starr's Mountain in Tennessee. The nature of the

pebbles entering into the composition of the breccia in Tennessee was not examined. In the masses found in this hill near Cartersville barite was a notable constituent. This hill was succeeded by a wide valley in shale. East of this valley and bordering the Etowah River a second ridge was passed through, showing in the railroad-cut a light colored decomposing siliceous gneiss dipping 45° E. This gneiss seemed the undoubted equivalent of the Knox sandstone. East of the river a wide valley in shale is crossed, deep red in color, arising from the decomposition of iron-bearing rocks. Succeeding this the road skirts the base of a lofty hill (500 feet), composed entirely of dense quartzite. This occurred in the horizon of the Chilhowee and was regarded as its equivalent. Beyond this, near Stegalls a long cut was passed in shale. Decomposing masses in this shale were of the same texture and nature as the masses observed in the hill near Cartersville. After passing Stegalls, and just before reaching the Bartow Iron Works a cut in heavy shale showed a layer of very dark colored slaty shale. South of the Iron Works a vertical strata of the same dark colored slaty shale filled with conformable quartz seams was found. Just south of this a very high hill showed the same shale more siliceous and metamorphosed into a very hard micaceous gneiss containing large quartz masses. In a cut, before reaching Allatoona, vertical walls were found, composed of quartzitic gneiss with slaty layers, the slate dark colored. Two cuts beyond Allatoona showed, the first, a schistose chloritic shale bed; the second very dark slaty shale containing quartz masses. From the sharp and rugged topography of the country, and the quantity of very dark slaty shale, the strata passed over since leaving Stegalls were supposed to be the equivalent of the Ocoee. The formations were all conformable with dips varying from vertical to S.E. at high angles.

In the second cut beyond the last a massive porphyritic gneissoid rock was found. Upon its weathered surfaces this rock presented a mottled appearance, and upon fracture showed a greenish hornblende matrix enclosing an almost equal amount of white feldspar. The feldspar was determined to be orthoclase. This rock was regarded as a metamorphic form of the Ocoee. (A rock with identical characteristics was found afterward near Talking Rock, Georgia, on the eastern flank of the Coosawattee Hills.) This rock was met with in three successive cuts.

Succeeding this formation the topography of the country changed. The sharp hills disappeared giving place to low rounded ridges composed of sandy soil, no true rock could be seen. This was succeeded at Acworth by a long cut through

a deeply decomposed hornblende slate, giving rise to deep red soil. These two latter formations were supposed to be the equivalents of the Knox sandstone and shale. They are just such forms as are seen along the Air Line railroad where that road passes near the limestone about Gainesville and Clarkesville, Ga. The limestone at these latter places was regarded by Bradley as the limestone of the Knox Group.

SECTION IV.—FROM DALTON, GEORGIA, THROUGH ELIJAY TO ARMACOLOLA, GEORGIA, AND FROM ARMACOLOLA THROUGH JASPER TO DALTON.

Dalton is situated upon the Knox dolomite. Between Dalton and Spring Place the Knox Group forms nearly the entire surface of the country. For two miles out from Dalton the regular succession of dolomite ridges and shale valleys is well marked and easily recognized, but no sandstone appears. Succeeding this, the characteristic regularity of the Knox topography is lost. The shale largely predominates, in some places very siliceous. The hills that are crossed do not present the continuous ridge appearance but are low and irregular. Along the road the distinct succession of the different beds cannot be easily determined. At the crossing of the Connasauga River a blue limestone mass was found such as characterizes the Maclurea limestone as seen in Sequatchee Valley. I was informed by the owner of the land that heavy limestone ledges crossed the river above and below the road. Pebbles and cobbles of the Drift were found on the elevations from forty to fifty feet above the flood plain of the river. Beyond the Connasauga the regular succession of dolomite ridges and shale valleys recurred until Spring Place was reached.

Shortly after passing Spring Place the road enters the shale and turns northeast parallel with the strike of the formation. Much of this shale was very siliceous, giving rise to sandy road beds. Turning eastward and passing from this formation the road crosses the dolomite with its characteristic chert followed by the shale with its characteristic limestone. This limestone of the shale is so peculiar that it deserves notice. Wherever met it is a dove-colored rock filled with interlacing calcite veins. Even where, as in some of its outcrops between Jasper and Spring Place, it has assumed the shaly structure of the bed enveloping it, its smallest masses can still be identified by these calcite veins. This is a constant characteristic. It is important, for the peculiarity mentioned by Professor Tuomey as marking the limestone of the mica slate in South Carolina is stated in these words—"the (lime) rock at this place is blue and intersected with calcite veins."

At this point the road enters an embrasure in the Smoky Mountains. The Cohutta Mountains lie upon the north and Fort Mountain upon the south, about four miles apart. Between these the Knox Group sweeps in and extends three miles beyond the line of the main mountain chain. The last appearance of the limestone of the Knox shale was seen at Gregory's, at the eastern limit of this reëntering angle. At Gregory's, also, the Ocoee conglomerate was first seen. Immediately upon leaving Gregory's an ascent of the mountain chain was begun. Here the road winds over two subsidiary ridges, or offshoots from the mass of Fort Mountain. The rock was Ocoee conglomerate, a dense and massive quartzitic gneiss, with layers of dense blue-black slates. Dip about 50° E. After crossing the first ridge a descent was made into the valley of Holly Creek, and up this valley the road wound in a second ascent over a ridge composed of the same rock. After crossing the second ridge the country became much less mountainous and the rock much less massive. Dip still east and southeast. Two miles from the crossing of the last ridge night overtook the party, and three miles had to be traversed after dark before shelter could be reached at Mountain Town. The next morning it was found that a synclinal had been passed, as the dip of the gneiss was N.W. 50°. The gneiss was light colored, siliceous and friable, enclosing decomposing feldspar crystals. This synclinal is just in the southwestern extension of the Ducktown synclinal. The gneiss suggests the dove-colored gneiss found near Hendersonville, N. C.

The change in the color of the gneiss gives light colored and sandier roads, and the change of the structure and nature of the rock causes much less massive and precipitous hills. From Mountain Town for about three miles and a half no change was noticed in the dip. Semi-metamorphic shales compose the great mass of the formation, with only an occasional layer of the gneiss. Heavy beds of gneiss recurred again upon nearing Elijay, with a change in the dip to S.E. On account of the nature of the road the point at which the anticlinal had been crossed could not be identified. On the slopes of the descent to Elijay, (the town being in a wide valley,) a light, dove-colored gneiss was found, containing feldspar crystals identical with that observed on the road to Hendersonville. A fine specimen of kyanite was also picked up at this point. At Elijay I was informed of the marble bed south of the town on Tulona Creek, and was shown specimens which were identical with that seen at Murphy, N. C. Specimens of psilomelane and copper ore were also exhibited.

Northeast of Elijay a heavy mountain mass trends N.E. and S.W. The local name for this is "Blue Ridge," but it is en-

tirely separate from the true Blue Ridge which lies eighteen miles to the east of Elijay. As this so-called Blue Ridge extends S.E. toward Elijay, it diminishes in elevation and forms the eastern limit of the valley in which Elijay lies.

The trip from Elijay was continued eastward up Carticary River, and a section of this eastern ridge was obtained. The rock was a massive conglomerate, with S.E. dip at high angles. It was judged to be Ocoee. The road led up the eastern flank of this ridge for several miles, the same rock showing along the roadway. The road then turns eastward and crosses the Carticary River. Above the flood plain of this river, on either side, heavy beds of Drift pebbles and cobbles were noticed.

East of the Carticary the topography becomes much less rugged and rocky. Rounded hills are passed over, showing semi-metamorphic shales and hydromica schists, in which the dip could only be occasionally determined. The surface was strewn with quartz, arising from the denudation of the schists and the scattering of quartz fragments from the included veins. At Heath's a very heavy vein of rich gold quartz was crossed. Esquire Heath crushed and panned some specimens for investigation. This vein is in the southwestern extension of the gold quartz vein mentioned by Bradley as passing from the head waters of Hiwassee River southwestward, near Blairsville, Ga. The road over this section was on a comparatively level plateau, and the true Blue Ridge could be seen a few miles east of Heath's as rather a low and unimposing line of lofty hills. The road from Heath's to the Blue Ridge continued in the same metamorphic shales with some schists; but little gneiss was seen. The succession of the dips could not be accurately followed from the nature of the formation. The Blue Ridge was not crossed by an ascent, but by a descent. The road led through a low gap in the ridge, and commenced a steep down grade. This descent continued for several miles by road. The rock was a massive heavy bedded gneiss, having such characteristics as elsewhere distinguished the Ocoee formation. This descent is over a monoclinal, dipping N.E. This great formation passes under the strata crossed over between Heath's and the point of descent. The Armacolola Falls is formed by the pitch of a stream over this precipitous monoclinal, and at the falls a fine section of the formation is obtained. Dip N.E. about 35°.

From Armacolola the road was taken southwestward to Jasper. The road ran approximately parallel to the monoclinal, constantly ascending to Burnt Mountain Gap. Burnt Mountain is a spur from the Blue Ridge, and in crossing it to reach Jasper, the level of the plateau is attained. From points along this ascent a clear idea could be obtained of the topography of

the surrounding country. The plateau traveled over from Elijay extended away to the northwest. Its level was approximately the same as Burnt Mountain Gap. Rising from it in the distance could be seen the mass of mountains near Elijay. To the southeast the hill country of eastern Georgia lay at least fifteen hundred feet below the level of the plateau.

Between Burnt Mountain Gap and Jasper the road descends. Sharp ridges were passed over, showing their bedded gneiss. The gneiss was neither so dark nor massive as the gneiss of the Blue Ridge monoclinal. The dips were irregular, varying as might be expected in a region of such disturbance. A mile before Jasper was reached the nature of the road changed, becoming level and smooth, suggesting a change in the formation.

Tate's marble quarry, two miles southeast of Jasper, was visited and examined. This locality is the one mentioned by Professor Bradley, and is exceedingly interesting on account of the light it throws upon the true age of some of the gneiss met in the preceding sections. The marble is exposed on the eastern side of a very deep and narrow valley. The exposure of the marble is about thirty feet thick, at the base of a precipitous ridge. The ridge is composed of mica schist and gneiss. The gneiss and the marble dip 40° E. On the west of the valley a sharp ridge rises, the summit of which is probably one hundred feet above the valley level. The top of this western ridge is approximately on the same plane as Jasper, so that the valley represents rather a deep trench in the formation. The western ridge is composed of thinly bedded gneiss, dipping S.E. under the marble. Some layers were light colored and filled with feldspar crystals, such as characterize the layer found west of Elijay and near Hendersonville, N. C.

If the gneiss of this ridge is metamorphosed Knox sandstone, which seems the only possible conclusion, it gives a clue to the age of the formations with which it occurs elsewhere. Here it immediately underlies the marble which shows some tremolite, as does the marble at Murphy. The marble bed in the Elijay Valley is also east of the beds of the same gneiss found upon the western slopes descending toward Elijay. From the relations of the gneiss at the Jasper marble quarry it would seem proper to refer the gneisses and semi-metamorphosed shales between Mountain Town and Elijay to the Knox. The same assignment would be necessary for the formations between Heath's and the Blue Ridge monoclinal.

The trip from Jasper to Spring Place was somewhat of a reversal of the section north of it through Elijay. The only difference being that Jasper is at the southwestern extremity of the Blue Ridge, or at least of that massive monoclinal which

gives the lofty mountains. Jasper is twenty-two hundred feet above the sea, but the mountains fade out northeast of it. Southwest of Jasper the "divide" is continued towards the southern extension of the Smoky Mountains, but no mountains proper are seen. The country northwest of Jasper over which the road to Spring Place leads is rolling but not rocky. The roadway is smooth and light colored, just such as is given by the Knox Group in Georgia and Tennessee. Two miles out from Jasper towards Talking Rock two ridges were crossed showing much quartzite strewed over the surface. Beyond this shale occurs with northwest dips, followed by an exposure of thin bedded gneiss with the same dip. The road continued on over shales with a recurrence, five miles from Jasper, of gneiss dipping N. 30°. At this latter point was found some dove-colored gneiss with feldspar crystals. The country beyond this was comparatively open and level in shale. This was succeeded by a ridge showing gneiss with N.W. dips, followed by a synclinal in the shale. The shale with S.E. dips continued through a wide valley bounded by a ridge covered with quartzite pebbles and showing beds of mica schists.

Ten miles from Jasper at Talking Rock Creek a bed of porphyritic gneiss was found similar to that found in Section III on the W. & Atlantic railroad. The bed on the W. & Atlantic railroad was found just between the metamorphic beds on the west, supposed to be Ocoee, and the gneissoid beds and decomposing hornblende slates on the east, near Acworth, supposed to be Knox. The relative position at Talking Rock was the same, namely, the shales and light colored gneisses lying east toward Jasper, being Knox, while toward the west was encountered undoubted Ocoee. Over this country to the west the road crossed and wound in among the heavy ridges of the Coosawattee hills composed of Ocoee gneiss and shale. The typical dense and massive Ocoee gneiss with its accompanying black slate was encountered only upon the western slopes of this belt where the formation borders upon the Knox Group. From the Coosawattee River (which was crossed just at the junction of the Ocoee with the Knox), to Spring Place the regular succession of the Knox Group was encountered. Fine exposures of the limestone of the shale show just after crossing the river near Nolan's. Beyond this to Spring Place the shale predominates. The limestone of the shale passes into a shaly condition, still retaining, however, the calcite veins in its smallest masses. No typical Knox sandstone was seen, but some prominent ridges were crossed composed of very siliceous shale and were regarded as the possible representatives of the Knox sandstone.

Conclusions.

The characteristics from which conclusions can be drawn concerning the age of the formations crossed in the several sections, are:

Relative position, lithological peculiarities and topography.

In these conclusions the fourth section will be considered first. The formation that permits no question as to its geological place is the marble bed at Jasper. No one who examines the Jasper marble and the marble at Murphy can hesitate as to the identity of the two. Professor Bradley, who examined the marble at Elijay, regarded that also as the same. Taking this as a fixed horizon from which age can be reckoned we find at Jasper a gneiss underlying the marble and so situated as to leave but little doubt that it is the equivalent of the Knox sandstone. This gneiss has certain characteristics that render it easy of recognition elsewhere, even when the marble does not accompany it. It is a light colored friable rock containing feldspar crystals; some of the layers are dove-colored, while others are drab. The dove-colored layer is so marked as to be instantly recognized wherever seen. These varieties of the gneiss are found together in the ridge west of the marble bed at Jasper. They differ from the Ocoee gneiss in being softer, and even "sandy," while the Ocoee is quartzitic and dense; in being thin bedded, while the Ocoee is generally thick bedded and massive; in being light colored, while the Ocoee gneiss is dark. Wherever these lighter colored gneisses are found the topography is hilly rather than mountainous, and these lighter colored gneisses are always accompanied with semi-metamorphic shales (also light colored where metamorphism is *partial*) which constitute by far the greater mass of the formation into which the two classes of rocks enter. These peculiarities when once recognized enable the observer to identify these formations wherever seen.

The light colored gneiss was found in the N.W. dips of Wolf Mountain east of the Ducktown synclinal. They were found in the N.W. dips of the synclinal passed near Mountain Town. The dove-colored gneiss was found dipping S.E. under the marble at Jasper, and was found near Elijay where it must have been below the marble on Tulona Creek. It was also found between Jasper and Talking Rock in strata that were, from other considerations, deemed to be Knox. This same dove-colored gneiss was found near Hendersonville where it was judged to be above the supposed Ocoee of Cæsar's Head and Table Rock. In all of these positions the gneiss formations are associated with semi-metamorphic shales, or where metamorphism is more complete, with hydromica schists.

It should be stated that these lighter colored gneisses were at first regarded as varied forms of the Ocoee, but a final review of the sections, in the light of the Jasper beds, warrants, it is believed, the conclusions that follow. These conclusions briefly stated, are:

1st. That the plateau land of northeast Georgia is based upon a great synclinal in the Ocoee.

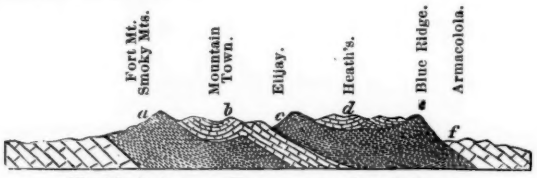
2d. That the Great Smoky Mountains may be regarded as the western monoclinal edge of this synclinal and the Blue Ridge as the eastern.

3d. That the great mass of the strata lying between these mountain chains in Georgia are above and younger than the Ocoee, and are composed chiefly of the metamorphosed equivalents of the Knox Group.

4th. That the formations east of the Blue Ridge are the metamorphosed equivalents of the Knox Group.

5. That the porphyritic gneiss of the W. & Atlantic railroad section is identical with the porphyritic gneiss found near Talking Rock and is a form of the Ocoee.

The second conclusion given above needs some qualification. In the Ocoee Gorge in Tennessee there are several faults in the Ocoee which would cause a repetition of monoclinal edges before the formation disappears as a final synclinal. This same characteristic marks the section of the Ocoee between Gregory's and Mountain Town, and between Talking Rock and the Coosawattee River. If the ridge east of Elijay is true Ocoee this general idea would require further modification as shown in the accompanying figure.



The blocked areas, Knox group; dotted, Ocoee.

The fourth conclusion is based upon the facts:

1st. That Professor Bradley regarded the limestone near Gainsville and Clarkesville, Ga., as of the same age as the Jasper marble.

2d. That the limerock spoken of by Professor Tuomey as occurring in South Carolina was by him regarded as identical with the limestone of northeast Georgia.

3d. That Professor Tuomey speaks of the limerock in Spartanburg and Laurens as of two kinds; the "limerock of the gneiss" and the "limerock of the mica slate." The former he

states contains actinolite (corresponding with the tremolite-bearing marble of Murphy, Knox dolomite), and the latter as being filled with interlacing calcite veins (corresponding with the limestone of the Knox shale wherever found).

Further, the Knox Group is easily followed from Tennessee to Cartersville, Georgia. These Knox beds are separated by but a few miles of Ocoee from metamorphic beds composed of just such forms as could be expected from the Knox Group. These latter beds are, moreover, east of the trend of the Ocoee of the Smoky Mountains as are the representatives of the Knox Group between Jasper and Talking Rock. Moreover, the Air Line railroad from Atlanta to Spartanburg, S. C., runs parallel with the strike of the strata east of the Blue Ridge and the same beds noticed near Acworth, i. e., sandy light colored gneiss, with mica schists and hornblende slates, show in every cut of the road. In these latter beds also occur the limerock of northeast Georgia and South Carolina.

These conclusions would require that the monoclinal of the Blue Ridge was formed by a downward faulting of the strata to the east of chain, and that along this line there has been sufficient displacement to separate the Knox strata of the plateau by two thousand feet from the same formation along the eastern flank of the chain. It is recognized that the conclusions here offered may seem more sweeping than the sections warrant; and it is also recognized that the work done has been after the manner of geological reconnaissances rather than of detailed surveys. When, however, it is remembered that in the four sections given the different formations have been crossed and recrossed six times; that these formations are marked by peculiarities of structure that are strikingly characteristic, and that they present a topography singularly uniform over immense areas, the conclusions will perhaps be deemed less inexcusable.

The writer takes pleasure in acknowledging his indebtedness to Professor Safford, whose report upon the Geology of Tennessee has been his guide in the study of these Lower Silurian formations; to Professor Bradley, whose section through these metamorphic areas he has carefully studied; and to Mr. Arthur M. Huger, of Charleston, S. C., to whom he is indebted for valuable information and suggestions, and for many collections of typical specimens from the formations traversed.

ART. XXXI.—*The Evolution of the American Trotting-Horse;* by WM. H. BREWER.

THE American trotting-horse is an example of a new breed of animals in process of formation. As yet it can hardly be called a definite breed in which the special and distinctive character is either fully developed in quality or satisfactorily fixed by heredity. Great progress has, however, been made, many individual animals have attained great speed, and all the better ones have derived their trotting excellence in part, at least, through heredity.

The origin of most breeds is involved in considerable obscurity, as to how much they are due to conscious and how much to unconscious selection, what motives led to this selection, how far the enhancement of the special qualities have been due to physical environment and how far to education, training, nourishment or cultivation. The formation of this new breed is so recent, the development of a special quality has been so marked, there is such an abundant literature pertaining to its history, the system of sporting "records" is so carefully planned and comprehensively conducted, and withal has become so extensive that we have the data for a reasonably accurate determination of the influences at work which led to this new breed being made, the materials of which it is made, and the rate of progress of the special evolution.

It is as an implement of gambling and sport that the trotter has his chief value to the biological student. Sporting events are published or recorded as the mere every-day use of animals is not, and the records of races give numerical data by which to measure the rate of progress. Similar data do not exist for the study of the evolution of any other breed.

Incidental to the preparation of a paper pertaining to this matter for farmers and breeders, I have compiled and collated certain data which have a scientific as well as economic value, the more interesting portion of which I condense for this paper.

The horse has several gaits which he uses naturally, that is, instinctively. And besides those which are natural he has been taught several artificial ones, some of which have been much used, particularly in the middle ages. But to trot fast was not natural to horses; when urged to speed they never assumed it, and until within a century the gait was neither cultivated nor wanted by any class of horsemen. A breed of fast trotters, had it been miraculously created, would doubtless soon have perished in that it would have had no use, satisfied no fancy and found no place in either the social or industrial world as it then was.

Before the present century the chief and almost sole uses of the horse were as an implement of war, an instrument of sport and ceremony, an index of rank and wealth and an article of luxury.

For all these uses, as then pursued, a fast trotter was not suited, nor was he better adapted to the heavy coaches over rough roads, or the slow wagon trains of armies. The horse best adapted to all these, however much he may have varied as to size, strength and fleetness, was one whose fast gait was the gallop or run rather than the trot. For leisurely horseback traveling the ambling gait (or *pacing* gait as it came to be called in this country), was preferred. With increasing use of horses for draft, certain heavy but slow breeds were developed in the Old World, of which the Dutch, Clydesdale and Norman breeds are examples.

The causes which led to the cultivation of the trotting gait in this country, and the evolution of a breed with which it should be instinctively the fast gait were various, and the separate value of each as a factor in the problem would be very differently estimated by different persons studying the subject from different points of view. Now that he is so valuable and plays such a part as a horse of use, it is easy to see why a breed of trotting roadsters should be produced to meet certain important demands of our modern civilization. But this does not explain how the process actually begun.

Reasoning *a priori*, the trotter, as a horse of use, should have originated in western Europe; as a matter of fact, he not only did not begin there, but he was unpopular there until well developed here. Locomotives began to draw armies to the battle-field, the war-horse declined in actual as well as relative importance, the modern, light, steel-spring, one-horse, convenient, business wagon as well as the modern buggy came into common use after trotting as a sport was established and after the gait had been extensively cultivated and bred to. The trotting-horse is specially adapted to various modern uses, but these uses followed his development, rather than led it, although in later days this factor has been an important one on the rate of progress.

The influences which originally led to the starting of the breed were more social than economical; a similar fact a century earlier marked the founding of that famous running breed, the English Thoroughbred. The origin of the trotter, however, was not so simple as that and several diverse social factors were involved, only the chief of which will here be noticed.

From early colonial times horses have been more generally owned by the masses of the people here than in any country of western Europe. They have had a more general use in agri-

culture and in business, their ownership or possession has had less social significance, and they have had less importance as instruments of gambling. The colonists who settled north of Delaware Bay, although of various nationalities, were largely those whose religious prejudices and social education was opposed to horse-racing. With the great majority of them it was considered a sort of aristocratic sport and at best led to unthrifty ways, even if not open to the objection of positive immorality. Consequently but few race-horses were imported into this region in colonial times. The original horse stock of the northern colonies came from several European sources. England, Holland, France and Spain certainly, and Sweden, Denmark, Germany, Ireland and Italy probably contributed to it. The blood from this variety of sources, variously mingled, formed the mongrel stock of the country. This was further modified by local conditions and local breeding assuming different characters in different places, and the hardships of horse life incident to a new country, with strange forage and a rough climate, caused deterioration in size and form. Early writers are unanimous on this point, but many add that what was lost in size and beauty was gained in hardiness and other useful qualities.

After the war of independence there was an improvement in the live stock of the country. English Thoroughbred horses were imported both for sporting and to improve the horse stock of the country, and horse-racing rapidly grew in favor as wealth and leisure increased. The export trade in horses to the West Indies increased, particularly from New England. Pacers were most sought for this trade, but sometimes trotters were advertised for.

As horse-racing increased in the last years of the last century the opposition to it revived, and in the earlier years of the present century this became ascendant, and stringent laws forbidding the sport were passed in most of the northern States. The prohibition was sweeping and the penalties severe.

Horse-racing was then a contest between running-horses, and during this repression of racing, trotting as a sport began, at first in a very unostentatious, irregular and innocent sort of way. Probably no people or class of people have ever bred good horses which they prized and were proud of, who did not find pleasure in seeing them compete in speed or show their fleetness in some way, and during the repression of racing (which meant running), trotting came in as a substitute, poor though it was at first. It had a sort of encouragement from very many thrifty people who were not sportsmen, and was in a measure considered a sort of democratic sport in which even plow-horses could take part. Racing of any kind in those

days was a strife between two or more things, as it still is in most countries; no one thought that a single horse could run a race alone, but the instinctive inclination to see a spirited horse in action could be mildly gratified by letting him trot, even if single and alone, and testing by the watch how quickly a given distance could be covered. So "timing" animals came to be practised. We hear of it on the Harlem race-course in 1806, four years after the laws forbidding horse-racing had been enacted, and again, a little later, near Boston, and it was reputed that certain horses could trot a mile in three minutes. This speed seemed so extraordinary that in 1818 a bet of a thousand dollars was staked (and lost) that no horse could be found that could trot a mile in three minutes. Some authorities date the beginning of trotting as a sport with this event. It is said that in betting the odds against the successful performance of the feat were great, which shows, strikingly, the enormous progress since made in developing speed at this gait.

In 1821, certain persons on Long Island were allowed by special statute to train, trot, etc., horses on a certain track, under certain restrictions, exempt from the penalties against horse-racing. Other organizations followed, and by 1830 the "training" of trotters was going on at several points, and trotting may be said to have become established as a sport. During this decade the record had been successively lowered to 2.40, 2.34 and 2.32. The times of performance were carefully taken at these "trials of speed," as the statute called them, and "records" became established by more formal sporting codes.

The ostensible object of these associations was the "improvement of the breed of roadsters;" driving single horses to wagons became fashionable and this led to the improvement of light one-horse wagons for business and pleasure. Those with steel springs were rare luxuries in 1830; by 1843, when the record of mile heats dropped to below 2.30, they were already common. During this thirteen years, the record had been lowered only half a second on mile heats, but three-minute horses were no longer rare.

The fashion of wealthy men driving a single fast trotter for pleasure was for a long time a peculiarly American one, and played an important part in the development of this breed. But, as stated earlier, many influences have contributed; changes in the modes of travel, changes in the methods of war, sentiments regarding horse-racing, the incentives of the course, the general improvement of roads, improvement in carriages, the needs of modern business requiring quick roadsters, these and other influences have all been at work.*

* For more details regarding the history of this development and the factors involved, see the paper already cited, Rep. Conn. Bd. Agr. for 1882, p. 215.

The material out of which this new breed is made is a liberal infusion of English Thoroughbred blood (usually more than two generations removed), with the mongrel country stock, previously described. There is a voluminous literature relating to special pedigrees and much speculation as to the comparative merits of the several ingredients of this composite blood.

Regarding the ideal trotter there is as yet a difference of opinion as to what the form should be, and it is too early to decide from actual results. That the gait is now hereditary, that it is the instinctive fast gait with some animals is certain, but whether this is due to inherited habit, inherited training, or to mere adventitious variation and selection, I will not discuss.

The gain in speed is given in the following table, which is the best records at mile heats, omitting the names of the special performers:

Date.	Best Record.	Date.	Best Record.
1818,	3.	1865,	2.18¼
1824,	2.40	1866,	2.18
"	2.34	1867,	2.17½
1830,	2.32	1871,	2.17
1834,	2.31½	1872,	2.16¾
1843,	2.28	1874,	2.14
1844,	2.26½	1878,	2.13½
1852,	2.26	1879,	2.12¾
1853,	2.25½	1880,	2.10¾
1856,	2.24½	1881,	2.10½
1859,	2.19¾		

A sporting paper published in 1873 a list of three hundred and twenty-three horses, with their best records, down to the close of the preceding year. This first list of the kind known to me was very imperfect in its details; it was revised for the next year, and since that time many lists, in one form or another, have been published. The figures for the animals with records of 2.25, or better, are reasonably accurate; for the others there is much discrepancy. In the following table the numbers are my own, counting down to 1872, inclusive; the numbers after that date are derived from various lists published since that time in the sporting and breeding periodicals. From the very nature of the case, the table cannot be accurate in the larger numbers, but the numbers do not lose their value for comparison with each other from such faults as to the details of the larger numbers, and as such, it is undoubtedly the most significant series of numbers ever compiled to show progress in evolution, whether of a breed or species. The number of horses with records of 2.40, or better, is now stated to be over five thousand.

I leave it to mathematicians to plot the curves which immediately suggest themselves, and determine how fast horses will ultimately trot and when this maximum will be reached.

TABLE SHOWING THE NUMBERS OF HORSES UNDER THE RESPECTIVE RECORDS.

	2:30 or better.	2:27 or better.	2:25 or better.	2:23 or better.	2:21 or better.	2:19 or better.	2:17 or better.	2:15 or better.	2:13 or better.	2:11 or better.
1843	1									
1844	2	1								
1849	7	2								
1852	10	3								
1853	14	5								
1854	16	6								
1855	19	6								
1856	24	7	1							
1857	26	7	2							
1858	30	7	2							
1859	32	9	2	1	1					
1860	40	11	4	2	1					
1861	48	14	4	2	1					
1862	54	17	7	4	1					
1863	59	19	9	4	1					
1864	66	22	12	4	1					
1865	84	29	15	5	2	1				
1866	101	32	17	6	3	1				
1867	124	42	21	9	5	2				
1868	146	52	28	13	6	2				
1869	171	63	34	15	10	4				
1870	194	72	35	16	11	5				
1871	233	99	40	17	12	6	1			
1872	323	--	--	--	--	--	--			
1873	376	--	74	28	15	5	2			
1874	506	--	98	40	16	11	5	1		
1875	--	--	134	61	30	13	5	2		
1876	794	--	165	81	39	16	6	2		
1877	836	--	214	105	51	19	8	2		
1878	1,025	--	270	129	68	24	9	4		
1879	1,142	--	325	164	88	33	11	5	1	
1880	1,210	--	366	192	106	41	14	6	2	1
1881	1,532	--	419	227	126	49	15	7	2	1
1882	1,684	--	495	275	156	60	18	8	2	1

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Reciprocal Displacement of the Halogens.*—The ready displacement of bromine by chlorine is a well-known fact. It takes place with a notable evolution of heat, 4·6 calories being set free for each equivalent of the halogen brought into action when KBr is used, 6·8 calories when $BaBr_2$ is employed, but only 1·5 calories when AgBr is acted on. In consequence of the publication by Potilitzine, of some experiments tending to show the simultaneous production of the inverse reaction, Berthelot has been led to repeat the experiment, in order to examine more closely the thermo-chemical conditions. In this investigation he has discovered real intermediate compounds, hitherto unsuspected, such as metallic perbromides, bromine chloride and metallic chlorobromides, formed in these inverse reactions, the heat of formation and of dissociation of which explain the phenomena observed. Thus his experiments showed that KCl, acted on by one equivalent of pure bromine, produced no appreciable effect either cold or hot. With three equivalents of bromide the same result took place; but with nineteen equivalents, an hour and a quarter of heating to redness and four distillations backward and forward, 5·5 per cent of the chloride was decomposed. After four hours and nine distillations, 7·8 per cent was displaced. With $BaCl_2$, treated with twenty-one equivalents of bromine, after four hours of heating to redness and eight distillations, 23·2 per cent was decomposed. With AgCl, with two equivalents of Br in the cold five days, 4 per cent was decomposed. With seven equivalents, in the cold five days, 7·2 per cent. With twenty-one equivalents, at a red heat for three hours, six distillations, 97 per cent. Now bromine chloride is a product common to all these reactions; and gaseous bromine uniting with gaseous chlorine produces liquid BrCl evolving 4·6 calories. Hence, this heat of formation suffices to explain the partial decomposition of silver chloride by bromine in the cold: $AgCl + Br_2$ (gas) $= AgBr + BrCl$; $-1·5 + 4·6 = 3·1$ calories. So with the perbromides: $KBr + Br_2$ (gas) $= KBr_3$ evolves 10·9 calories if the product is solid, 11·5 if dissolved. $BaBr_2 + Br_4$ (gas) $= BaBr_6$ evolves 20·8 calories when dissolved. The heat of formation of these bodies accounts for the inverse reactions of potassium and barium chlorides: $KCl + Br_4 = KBr_3 + BrCl$: $-4·6 + 4·6 + 10·9 = +10·9$ calories. And $BaBr_2 + Br_8 = BaBr_6 + (BrCl)_2$: $-13·6 + 9·2 + 20·8 = +16·4$ calories. Again, the chlorobromide of barium evolves heat as follows: $BaCl_2 + BaBr_2 = Ba_2Cl_2Br_2 + 3·0$ calories. It therefore assists in the same direction. In certain chemical reactions the action is at first prompt, but becomes more and more slow as it goes on. The author attributes this to the formation of certain double salts and secondary compounds, the heat of combination of which exceeds the heat called into play in the direct decomposition of the simple

salts. These secondary compounds resist the first action and they would resist indefinitely if they were not dissociable by the heat. Their slow dissociation, however, is determined by the destruction of the simple salts which maintained the equilibrium, the same simple salts normally yielded by the reaction being reproduced. —*Bull. Soc. Ch.*, II, xxxix, 58, Jan., 1883. G. F. B.

2. *On the Action of Nascent Hydrogen in increasing the Activity of Oxygen.*—Some time ago HOPPE-SEYLER published some experiments showing that hydrogen in the nascent state, in presence of oxygen, induced energetic oxidation. Traube having called in question both the experiments and their explanation, the author has repeated them. He finds (1) that palladium-hydrogen in contact with oxygen colors potassium iodide and starch solution blue; (2) that these same bodies by their mutual action oxidize indigo-carmine solution to a yellow color; (3) that they oxidize oxyhæmoglobin solution to methæmoglobin; and (4) that they oxidize ammonia to nitrous acid. When recently ignited palladium is used instead of palladium-hydrogen, no such oxidation takes place, even in presence of hydrogen peroxide—contrary to the assertion of Traube. Recently ignited platinum or palladium foil placed in a mixture of indigo-carmine solution with hydrogen peroxide, causes no change, the liquid retaining its blue color for many days; while the same mixture pales and becomes yellow if the palladium foil is previously charged with hydrogen. The presence of the hydrogen peroxide has no influence upon the progress of the oxidation. Oxyhæmoglobin decomposes hydrogen peroxide into water and inactive oxygen without change of its color; while active oxygen or ozone converts it into methæmoglobin. Whether hydrogen peroxide is reduced by hydrogen in the nascent state cannot be determined by means of palladium-hydrogen, since it is decomposed by palladium itself into water and oxygen. But if to hydrogen peroxide, ferrous salts or other salts which are oxidized by ordinary oxygen be added, active oxidation takes place of indigo-carmine solution and the like, corresponding with the hypothesis of increased oxidation-activity by reduction. In the same way, benzene agitated with ignited palladium and air gives no result, while phenol is formed if the palladium contains hydrogen; and in greater quantity the more highly is it charged with the gas. So petroleum ether, when agitated with sodium hydrate and air, gives scarcely traces of oxidized products, even after a long time; while in presence of slowly oxidizing sodium in addition, sufficient quantities of the products were obtained to allow of the separation of the alcohols and acids, determination of fusing points, oxidation of the alcohol by chromic acid and elementary analysis. The author calls attention to the similarity of the action of rhodium-black upon formic acid, observed by Deville and Debray, with the action of a ferment upon this acid. And as he shows that the former action is due to rhodium-hydrogen, which acts like palladium-hydrogen above, he suggests a similar action for ferments, thus throwing

some light upon a subject of great physiological importance.—*Ber. Berl. Chem. Ges.*, xvi, 117, Feb., 1883. G. F. B.

3. *On the Phosphorescent Flame of Sulphur.*—HEUMANN, having raised the question whether phosphorus among the metalloids was the only one which underwent slow combustion at a low temperature, becoming luminous, has answered it satisfactorily by experiment. He finds that sulphur shows this phenomenon very well, though of course at a temperature higher than is required for phosphorus. If a heated rod of glass be dipped in pulverized sulphur, it becomes covered with the fused material which takes fire. If now the blue flame be blown out, the sulphur still continues to burn but with a whitish flame visible distinctly only in the dark. This white phosphorescent light is seen much better when the sulphur is heated rapidly to 180° on a plate in the interior of a metallic air-bath. White flames ten to twenty centimeters long flicker through the entire box. By regulating the gas this slow combustion may be continued for an hour without the appearance of the blue flame. Various kinds of sulphur were tried with the same result. Moreover many compounds of sulphur act in the same way: cinnabar, antimonious sulphide, arsenous sulphide, aurum musivum, sodium thiosulphate, potassium xanthate, sulphurea, all showing the white flame. The odor emitted when the sulphur thus burns is peculiar, recalling that of hydrogen persulphide, camphor and ozone at once and is the odor ordinarily ascribed to sulphur vapor. On examining it closely, however, nothing could be recognized in it but sulphurous oxide.—*Ber. Berl. Chem. Ges.*, xvi, 139, Feb. 1883. G. F. B.

4. *On the Hydrates of the Sulphydrates.*—An extended memoir has appeared, by DE FORCRAND, upon a class of crystallized bodies formed when hydrogen sulphide, at a low temperature, is passed into certain organic liquids in presence of water. These compounds he calls sulphydrated hydrates. The compound with hydrogen sulphide itself was observed by Wöhler in 1840. It is formed when H_2S and water are enclosed in a strong tube, in proportion as the former is decomposed and the H_2S liquefied. Brilliant crystals appear under a pressure of 17 atmospheres at the ordinary temperature. On heating to 30° they disappear but re-form on cooling. The author made his experiments in the tube of a Cailletet apparatus where the pressures and temperatures could be measured. At 29° the crystals decompose even under a pressure of 23 atmospheres. At 30° they are destroyed at 50 atmospheres. At low temperatures, however, the tension of dissociation is very feeble. On analysis the crystals contained from 12·4 to 16·6 molecules of water for one of H_2S. As the water was in excess in the latter, the author prefers the formula $H_2S(H_2O)_{12}$. In the first chapter of the memoir, the formation, crystalline form and composition of the sulphydrated hydrates of the simple ethers of the fatty series and of their chlorine, bromine and iodine derivatives, are described. Forty-eight substances were examined and of these thirty yielded the sulphydrated hydrate. The general

formula of these hydrates is $M+(H_2S)_2+(H_2O)_{23}$; that is, they are composed of two hydrogen sulphide hydrate groups, in one of which a molecule of ether has replaced one of water. The crystalline form of all these hydrates is the regular octahedron. In the second chapter the tension of dissociation and in the third the heat of formation of these hydrates is discussed. In chapter fourth similar bodies are described obtained with hydrogen selenide.—*Ann. Chem. Phys.*, V, xxviii, 5, Jan., 1883. G. F. B.

5. *On Brominated Carbon compounds produced in the Bromine manufacture.*—Dyson has examined a liquid obtained as a bye-product in the bromine manufacture. It distilled almost entirely between 82° and 172°, leaving some crystals of carbon tetrabromide in the flask. On fractioning, the main portion distilled over at 148°–150° and consisted of bromoform. The next largest fractions boiled from 121°–123° and from 123°–125°. They consisted of chlorobromoform, $CHBr_2Cl$, giving on analysis 75·97 per cent of bromine and having a vapor density of 105·8, while theory requires 76·76 and 104·2 respectively. Its specific gravity at 20° was 2·477. Bromoform and carbon tetrabromide have been before observed as bye-products by Hermann and Hamilton. But the author thinks this is the first discovery of chlorobromoform in bromine.—*J. Chem. Soc.*, xliii, 36, Feb., 1883. G. F. B.

6. *Change in the double refraction of quartz produced by electrical forces.*—It is proved by W. C. Röntgen that the double refraction of quartz may be modified by placing it in an electric field. It increases if one end of the secondary axis, which becomes negatively electrified under pressure transmitted along this axis, is electrified positively and the other end electrified negatively. The double refraction is diminished when this distribution of charges is reversed. No change in double refraction was observed when the electric forces acted in the axis of no piezoelectricity—at least with the electric field employed by the author. The axes of no piezoelectricity are defined.—*Ann. der Physik und Chemie*, No. 2, pp. 213–233, 1883. J. T.

7. *Optical behavior of quartz in an electrical field.*—A. Kundt confirms the results of Röntgen upon the change of the double refraction in quartz due to electrical stress. Figures are given which show the action of electrical stress upon the optical phenomena. The compressive and dilative effects in hemimorphic crystals placed in an electrical field can be explained by the piezoelectric effects noticed in such crystals.—*Ann. der Physik und Chemie*, No. 2, pp. 228–233, 1883. J. T.

8. *Magnetic storms.*—M. Mascart has communicated to the French Academy the information that the great magnetic storm of November 17, 1882, was also observed at Cape Horn. According to M. LeCannellier, one of the officers attached to the mission, the storm began at five o'clock on the morning of November 17th and attained its full force during the following night. The declination changed 40′ in three hours and the two components underwent variations of the same order. Comparing these observa-

tions with those of M. Renou, taken at the Observatory of Parc Saint Maur and allowing for the difference of longitude, it is seen that the principal perturbation took place at the two places at the same time.—*Comptes Rendus*, p. 329, Jan. 29, 1883. J. T.

9. *Comet of* 1882.—In the Comptes Rendus of Sept. 25, 1882, M. THOLLON and M. GOUY gave the results of their observations upon this comet, and, by means of a spectroscope of one prism, proved that the sodium lines seen in the spectrum of the comet were displaced by an amount equal to one-quarter or one-fifth of the interval between the two sodium lines; and hence they concluded that the comet was receding from the earth with the velocity of 61^{km} per second. The late astronomical calculations of M. Bigourdan give 76^{km} as the mean velocity of recession. The near agreement of the two results appear to prove the accuracy of the spectroscope method of measuring the recession or approach of the heavenly bodies.—*Comptes Rendus*, p. 371, Feb. 5, 1883. J. T.

10. *The magnetising function of Steel and Nickel.*—Considerable diversity exists between the results of various observers upon the magnetic permeability of the magnetic metals. HUGO MEYER gives results obtained with weak magnetising forces. His method of experiment was to make the steel or iron cylinder the core of an earth inductor and to use the earth magnetic field. His observations lead him to conclude:

(1.) The magnetising function has a positive value for a diminishing magnetising force.

(2.) It increases at first with the magnetising force.

(3.) It increases for weak magnetising forces with the temperature.

The value of $k=2{\cdot}24$ for a magnetising force of $f=3{\cdot}096$ was obtained for pure nickel. Meyer believes that the latter result agrees fairly well with that obtained by Rowland for cast nickel when the difference between the magnetising force employed by the two observers is considered.—*Ann. der Physik und Chemie*, No. 2, pp. 233–253, 1883. J. T.

11. *Determinations of the Ohm.*—Professor G. CAREY FOSTER communicated to a meeting of the Physical Society held in London, January 27, a paper on a new method of determining the ohm which he had proposed in 1874. This method consisted in balancing the electromotive force set up in a coil spinning in the earth's magnetic field, through a wire by means of an opposing electromotive force from a given battery. The two opposing circuits through this wire R are composed, the first of the spinning coil and a zero galvanoscope, and the second of a battery and an absolute galvanometer; these two circuits meeting at the end of the wire R. By this method the values of 1·003 and ·999 were obtained in two trials. Further experiments will be made with increased precautions. Mr. Glazebrook called attention to the agreement between the results of Lord Rayleigh's determinations and his own independent ones. Lord Rayleigh's results are

·9893, ·9865, ·9868, and Mr. Glazebrook's is ·9866 or the mean of Lord Rayleigh's results. He also announced that the Cavendish laboratory, Cambridge, would soon be in a position to test and certify any resistance coils sent there. G. Lippman proposes an electrodynamic method for the determination of the ohm. This resembles Loreng's method. A coil is spun inside a long coil through which a given current is passing. The resistance to be determined is placed in the circuit of the latter coil. The electromotive force produced by the rotation of the inner coil is balanced along the given resistance by the electromotive force in the outer coil. By using a very long outer coil the calculation can be simplified.—*Nature*, Feb. 8, 1883; *Comptes Rendus*, pp. 1348–1350, Dec. 26, 1882. J. T.

II. Geology and Natural History.

1. *Palæo-geological and Geographical Maps of the British Islands and the adjoining parts of the Continent of Europe*; by Edward Hull, Director of the Geological Survey of Ireland. Roy. Dublin Soc., 2d ser., i, 257, 4to.—The fourteen maps which Professor Hull has here published represent the probable geographical and geological condition of northwestern Europe and Britain during successive eras from the "Laurentian," until the era of submergence after the era of the great glacier. They make a highly instructive series, interesting to the general geologist as much as to the European. The maps are accompanied by forty pages of text reviewing the facts which the maps illustrate. On the map of the Glacial period, the British area is wholly emerged and all under ice except the southern part of England, south of a line running across from the southwest corner of Wales to a point on the west coast, north of the Thames; that of the submergence 1,350 feet in N. Wales, etc. which followed, represents the British area as an archipelago, Ireland about five-sixths water, England four-fifths, and Wales and Scotland less than two-thirds; and that of the so-called Upper Glacial, or epoch of sub-glacial conditions, as about a fourth less under water than in the area of greatest submergence.

2. *The Geological Survey of Pennsylvania.*—The following volumes have recently been issued. *The Geology of Bedford and Fulton Counties*, by J. J. Stevenson. No. T2, 382 pp. 8vo, with two maps. Harrisburg, 1882. *The Geology of Pike and Monroe Counties*, by I. C. White; and *Special Surveys of the Delaware and Lehigh Water Gaps*, by H. M. Chance. No. G6. 408 pp. 8vo; with colored geological maps, a map of glacial scratches and sections, illustrating Mr. White's Report. 1882.

The Geology of Philadelphia County and of the southern parts of Montgomery and Bucks; by Charles E. Hull, with analyses of rocks, by Dr. F. A. Genth and F. A. Genth, Jr. No. C6. 146 pp. 8vo, with a colored geological map. 1881.

A further notice is deferred.

3. *Report on the Geological Survey of Ohio:* Zoology and Botany. Part I, Zoology; consisting of a Preface by Professor J. S. NEWBERRY; Report on the Mammals, by A. W. BRAYTON (185 pp.); on the Birds, by Dr. J. M. WHEATON (442 pp.); on the Reptiles and Amphibians, by Dr. W. H. SMITH (106 pp.); on the Fishes, by Dr. D. L. JORDAN (268 pp.). 8vo. Columbus, 1882.

4. *United States Geological Survey.*—The Congress, whose term has just expired, with commendable liberality appropriated for the Geological Survey a total sum of $341,140. This applies to the fiscal year beginning July 1, 1883 and ending June 30, 1884. The appropriation for the current fiscal year was $258,440, so that the provision for the coming year is on a much more liberal scale. The Bureau of Ethnology, which is likewise under the direction of Major Powell, had its appropriation raised from $35,000 to $40,000.

5. *Geological Survey of Alabama.*—The legislature of the State of Alabama has recently appropriated the sum of $50,000, to carry on the Geological Survey for the next ten years. It is proposed to devote the greater part of the work to the coal-fields, and to the region of the iron ores, since these, especially the former, have been hitherto almost untouched. During the past ten years the State Geologist has been obliged to work with only $500, and the present increase in the appropriation, although not as great as might have been desired, will make it possible to extend the work to a very important degree.

6. *Equivalency of the Lime Creek beds of Iowa;* note by H. S. WILLIAMS.—Since my paper, at page 97 of this volume, was published, I have learned that I was wrong in speaking of the rocks of Lime Creek, Iowa, as referred by western geologists to the Kinderhook group. How I was led astray by publications on the subject it is not important here to explain. I still hold it true that the exact relation of the Lime Creek beds to other deposits of the west is not satisfactorily determined, and that its fauna is represented in New York at the very base of the Chemung formation.

7. *Chondrodite and Humite.*—H. SJÖGREN has recently published the results of an investigation of two minerals of the chondrodite group from Sweden. It will be remembered that Scacchi originally described the Vesuvian humite as existing in "three types;" later it was shown that they were distinct minerals, though closely related; type I is orthorhombic and is now called *humite*, type II is monoclinic and is called *chondrodite*, type III is monoclinic and is called *clinohumite*. The crystals from Brewster, N. Y., have been shown to be chiefly chondrodite, though humite and clinohumite also occur sparingly. The crystals described by Sjögren from the Ladu mine, Wermland, Sweden, are holohedral orthorhombic and correspond to humite (type I) of Vesuvius; those from Kafveltorp belong to the species chondrodite as now defined. The crystals from the latter locality have been subjected to a thorough investigation by Sjögren (Lund

Univ. Års-skrift, xvii), who gives the results of many measurements and about sixty figures, showing the variety in form, the optical structure and so on. The measured angles agree closely with those of the Vesuvian chondrodite, less so with that from Brewster, and the optical constants are also nearer the former. The Kafveltorp mineral is also near the Vesuvian in the frequency with which the polysynthetic twin structure is observed, giving rise to much apparent irregularity in the angles.

8. *Arboretum Segrezianum: Icones Selectæ Arborum et Fruticum in Hostis Segrezianis Collectorum*, etc. Auct. ALPHONSE LAVALLÉE.—Two years ago we gave a short notice of the fasciculi, then published, of this admirable work. Two more have now reached us. The publication does not advance rapidly, but it will be understood that the work is in no respect of a commercial character, is the outcome of pure scientific devotion, and is of high critical character. Its author possesses and delights in the best collection of hardy shrubs, in a scientific point of view, that is now known. These livr., 5 and 6, carry the letter-press from page 65 to page 108, and the plates represent three species of *Pterocarya* (Trans-Caucasian and Chinese); two of our Atlantic U. States species of *Cratægus*, and one of the Old World; *Calycanthus floridus*, a variety with ovate leaves; *Actinidia volubilis* of Japan; *Schizandra Chinensis* Baill.; *Akebia quinata*, another Chino-Japanese climber, which is already well known in cultivation in the United States; *Clematis orientalis*, L., to which the author has reduced the Himalayan *C. graveolens*, Lindl., a species which we cultivate as far north as Canada, being perfectly hardy, in fruit ornamental, but the blossoms dull. Much may be expected from M. Lavallée's study of the species of *Cratægus* from the life. We were quite prepared to recognize *C. punctata* as a good species. We do not understand how the "*C. coccinea*, var. *cordata*," with its large flowers and large fruit, can be of the Linnæan species of that name; and we think it quite certain, on the authority of the original specimen, that the "*C. leucophlœus*, Mœnch," figured on tab. 22 *is* the *C. tomentosa* of Linnæus.

A. G.

9. *Color and Assimilation.* — TH. W. ENGELMANN has made an extensive use of the so-called Bacteria-method for investigating the effect of light on chlorophyll cells. In the Botanische Zeitung for January 5 he gives further details of his experiments and presents some of his conclusions. The effect of free oxygen upon quiescent bacteria is so great that by their presence the trillionth of a milligram of the gas can be detected. When a green cell in water is evolving oxygen, even in an extremely minute amount, the movements of the bacteria afford instantaneous indication of its presence. Moreover, when the ray of light, shining through or on the green cell, is unfavorable to the process of assimilation and the evolution of oxygen, the effect on the bacteria is at once shown. All of Engelmann's experiments were checked by control-observations, and appear to have been

conducted with care throughout. The results are mainly as follows: Only those cells which contain particles of colored protoplasm evolve oxygen in the light. When colorless protoplasm was screened by a colored solution, or was illuminated by light coming through a green leaf, no oxygen was evolved. It will be seen that this has a direct bearing upon some of Pringsheim's views. In the case of cells of different colors, e. g., Green, *Sphagnum* and *Spirogyra*, Yellowish-brown, *Navicula* and *Pinnularia*, Bluish-green, *Oscillatoria* and *Nostoc*, Red, *Callithamnion* and *Ceramium*, distinct relations between the color and the amount of assimilation under different rays were made out. The maximum activity for green cells was in the red between B and C (the place of the most striking of the chlorophyll absorption bands); for yellowish-brown, in the green, at D½E; for bluish-green, in the yellow; for red, in the green. Hence, there must be a series of colors other than that of chlorophyll which possess the power of assimilation in different parts of the spectrum. The maximum activity for a given color is found in rays complementary to that color. The author gives also an account of the possible bearing of the above on the distribution of organisms at different depths of water. G. L. G.

10. *On the Influence of Sunny and Shaded Localities on the Development of Foliage Leaves;* by E. STAHL (of Jena), (Zeit. f. Naturwissensch., XVI. N. F. IX, 1, 2. Also separately.)—Haberlandt, in an examination of the comparative anatomy of the assimilating tissues in plants, has come to the conclusion that light is almost without influence in governing the shape of leaves or the arrangement of the chlorophyll cells. On the other hand, Pick has shown that the shape and arrangement of assimilating tissues are certainly controlled to some extent by the presence of full sunlight or of shade. Both of the foregoing works were preceded by a paper by Stahl in which the influence of the intensity of light on the structure and arrangement of chlorophyll-parenchyma was pointed out. It may be further stated that the same author had previously studied the effect of the direction and intensity of light on some movements in plants. In the paper just published he incorporates some of the results earlier attained by him, and adds several facts of considerable interest. The thesis may be stated as follows: The elongated, or palisade cells, are best adapted for light of high intensity; the looser parenchyma for that of low intensity. (To this, in passing, may be added Areschoug's observation that the looser or spongy parenchyma is that best adapted for transpiration and characterizes the foliage of moist climates; where either local or climatic relations render too rapid transpiration undesirable, these layers are protected by a palisade system.) The author has devoted most attention to plants which can endure shade as well as bright sunlight, and here wide differences are alleged to exist between the forms growing in light and those found in shade. All the differences are of the character above described, namely, adaptation to

sunlight by the development of a better palisade system. The critical point of the investigation is plainly that leaves developing in sunlight have a less well-characterized spongy parenchyma, and a better marked palisade system. In view of the fact that these two systems are generally found as stated in the thesis, the author asks whether this ought not to influence our treatment of plants in green-houses. The paper and its illustrations are of great interest. G. L. G.

11. *Rabenhorst's Kryptogamen-Flora*, vol. II, parts 1–3.—We have already noticed in this Journal the earlier numbers of the first volume of this work, and now the first three parts of the second have just appeared containing the first part of the Marine Algæ by Hauck. The marine flora of Germany proper is, of course, of comparatively small account, being confined principally to species from Heligoland and the Baltic; but the Austrian species are numerous and interesting, and Hauck, who resides at Trieste, has had the great advantage of being able to study them on the spot. After a few pages devoted to a description of the manner of collecting and preparing specimens, there follows an account of the classification of the *Florideæ*, which are considered to form an order, the name family being applied to the divisions as *Porphyraceæ*, *Corallinaceæ*, etc. The parts already issued include the *Porphyraceæ*, *Squamariaceæ*, *Hildenbrandtiaceæ*, *Wrangeliaceæ*, *Helminthocladiaceæ*, *Chætangiaceæ*, *Ceramiaceæ*, *Spyridiaceæ*, *Cryptonemiaceæ*, *Gigartinaceæ*, and part of the *Rhodymeniaceæ*. The arrangement is, in general, that of J. G. Agardh as modified by the writings of Thuret and Bornet. The departure from previous classifications is most marked in the *Rhodymeniaceæ*, in which are included *Chylocladia* and *Chryshymenia*. In the first named genus is included our common *Champia parvula* Harv., and the *Chylocladia Baileyana* of our coast is merged in *C. uncinata* Menegh., to which no exception can be taken. Another innovation is the union of *Centroceras* with *Ceramium*, which also seems warranted.

The descriptions and synonymy are excellently managed by Hauck, and are accompanied by an astonishing number of good wood-cuts, principally after Thuret and Bornet and Kuetzing, the structure of the frond and fruit in each genus being figured, and in case of large genera, such as *Callithamnion*, several figures are given. There are besides three full-page photo-lithographs of *Corallineæ*. Altogether the work promises to be a model, and to furnish what has long been a desideratum, viz: a complete guide to the marine Algæ of the Germanic nations. To American students it will be especially welcome, as the numerous illustrations and excellent descriptions are furnished at a price within the reach of those who cannot afford to buy the larger illustrated works. W. G. F.

12. *Heteroecism of the Uredines;* by CHARLES B. PLOWRIGHT.—In two very interesting and important papers published in Grevillea and the Gardeners' Chronicle, for 1882, Mr. Plowright gives

his experiments on the connection of certain æcidial and teleutosporic forms of *Uredines*. His experiments were started in 1881 with cultures of the spores of *Æcidium Berberidis* on wheat; but as *Uredo linearis*, which is the uredo-stage of *Puccinia graminis*, appeared on the control plants as well as on those on which the æcidial spores were sown, he was not able to confirm the connection between *Æcidium Berberidis* and *Puccinia graminis* which is accepted by continental botanists. In 1882 he repeated his experiments on a larger scale and with a more satisfactory result. In the case of *Puccinia graminis*, the blight in grain, he not only succeeded in producing *Uredo linearis* on wheat by sowing the æcidial spores, the control plants remaining healthy, but he reversed the experiment and produced *Æcidium Berberidis* by sowing the *Puccinia* spores. He also sowed the spores of *Podisoma Sabinæ* and *P. Juniperi* on pear and Cratægus seedlings and produced *Rœstelia cancellata* and *R. lacerata*, respectively. The spores of *Gymnosporangium Juniperi*, sent from a distance of several hundred miles, when sown on *Sorbus Aucuparia* were followed by a growth of *Rœstelia cornuta*, a species never before seen by Plowright in Norfolk, where the experiment was made. He also experimented with other species of *Puccinia*, *Peridermium* and *Uromyces*, and succeeded in confirming the views of continental writers as to their secondary forms, in one instance producing a *Puccinia* not before known in Britain, and in the case of *Uromyces Junci* showing the relation to *Æcidium zonale* which was suspected by Fuckel.

No writer, since DeBary, has shown more successful results in this difficult subject, and Plowright deserves great praise for his careful experiments. Except in one series of cultures the fully developed æcidial form was obtained, and not the spermagonia alone, as had been the case with some other investigators. Although most of the experiments were rather in confirmation of those of other botanists, in a very important respect he has added to our previous knowledge. One great difficulty in the way of accepting the connection between *Æcidium Berberidis* and *Puccinia graminis*, especially in this country, has been that the *Puccinia* is very common in districts where the barberry is unknown, and according to DeBary the *Puccinia* spores cannot be made to germinate and grow upon grasses. Plowright, however, was able, in a limited number of cases, to make the *Puccinia* spores grow upon wheat, especially on young seedlings. Accepting this statement one can see how, in our Western States, the wheat blight could be propagated from year to year without the presence of barberry bushes. In this connection it is of interest to know the details of the provincial laws of Massachusetts relating to the enforced destruction of barberry bushes, in consequence of their supposed injurious influence on the grain crops. DeBary states that such laws existed, following the account of a German traveler, Schoepf. Through the kindness of Professor J. B. Ames, of the Harvard Law School, I have been

able to examine the laws on the subject. They are to be found in the Province Laws of Massachusetts, 1736–1761, p. 153, Anno Regni Regis Georgii II., Vicesimo Octavo, Chap. X, published Jan. 13, 1755. It is entitled, "An Act to prevent Damage to English Grain arising from Barberry Bushes." After a preamble stating that "it has been found by experience that the blasting of wheat and other English Grain is often occasioned by Barberry Bushes to the great loss and damage of the inhabitants of this province," there follows the enactment of the law, in six sections, in which owners of land containing barberry bushes are ordered to destroy them before June 13, 1760; and, if they do not do so, any person, after giving a month's notice, is at liberty to destroy the bushes and recover the cost of so doing from the owner of the land. Also surveyors of highways are ordered to cut down all barberry bushes growing on public land under penalty of a fine for non-performance. There are also several stringent regulations showing the importance attributed to the subject by the Government at the time. The act was to continue in force until June 10, 1764. W. G. F.

13. *Anatomical Technology as applied to the domestic Cat, an introduction to human, veterinary and comparative anatomy;* by BURT G. WILDER and SIMON H. GAGE. 8vo, 575 pp. with 130 cuts and 4 plates. A. S. Barnes & Co., New York and Chicago, 1882.—This is intended as a manual for use in laboratories of comparative anatomy, and will undoubtedly supply a want long felt by very many teachers. A large amount of space (148 pages) is devoted to introductory matters, such as descriptions of instruments and their use; preparation and preservation of specimens; the metric system; terminology; directions for injecting the vessels; "slip system of notes" (7 pages), etc. Most of this will doubtless be of help to beginners, and some of it to teachers as well, but some matters usually found in school books and dealers catalogues might have been omitted without much detriment to the general usefulness of the book, as an anatomical manual. The portion of the book relating specially to the anatomy of the cat contains descriptions of the brain, cranial nerves and sense-organs (130 pages, including a description of the amphibian brain) of the vascular and general nervous system; of the abdominal and thoracic viscera; of the skeleton; and of certain portions of the muscular system (fore-leg). At the end there is a list of the works cited. At first sight there seems to be a large number of new or unfamiliar technical words and expressions, some of which have no apparent advantage over those in common use. We do not see the advantage of saying of a cat, laid on its back, that it is "placed dorsicumbent." Nor does "dorsiduct the tail" seem to have any very striking advantage. But many of the reforms in the nomenclature of organs and parts seem to be judicious as well as useful. V.

14. *Mémoires concernant l'Histoire Naturelle de l'Empire Chinois par des Pères de la Compagnie de Jésus.* I cahier. Chang-

Hai: quarto, 55 pp., 12 plates.—This number contains two memoirs. The first is on *Trionyx*, illustrated by 10 lithographic plates, by P. M. Heude. Thirteen species are described. These are referred to nine genera, viz: *Yuen* (five species), *Psilognathus*, *Temnognathus*, *Gomphopelta*, *Cœlognathus*, *Tortisternum*, *Ceramopelta*, *Captopelta*, *Cinctisternum*. The second memoir, entitled, Étude sur le *Coccus pé-la*, is by G. Rathouis. It is illustrated by two plates, showing both sexes and their transformation, with some anatomical details. We understand that this work is to be continued. v.

III. Astronomy.

1. *Astronomical Papers of the American Ephemeris;* Vol. I. Washington, 1882.—This is the completed volume containing six papers, some of which have been heretofore distributed in separate form. The object of the series is stated to be a systematic determination of the constants of astronomy from the best existing data, a re-investigation of the theories of the celestial motions, and the preparation of tables, formulas and precepts for the construction of ephemerides. Four of the papers are by the superintendent, Professor Newcomb: Recurrence of Solar Eclipses, with tables of eclipses from B. C. 700 to A. D. 2300 (this Journal, xx, 79); a transformation of Hansen's Lunar Theory compared with the theory of Delaunay; Catalogue of 1098 standard clock and zodiacal stars; and a Discussion of observed Transits of Mercury. The two remaining papers are, An Experimental Determination of the Velocity of Light, by A. A. Michelson, and Gauss's method of computing secular perturbations, with an application to the action of Venus on Mercury, by G. W. Hill.

2. *Transits of Mercury* 1677–1881.—The sixth of the above papers, by Professor Newcomb, is an exhaustive discussion of all the transits of Mercury hitherto observed. An interesting portion of the discussion is that referring to the possibility of an inequality in the earth's rotation on its axis. Professor Newcomb had found that the moon's mean motion for about 250 years could be represented with approximate accuracy by the addition of a single term with a period not differing greatly from 300 years. Taking as the standard of time the earth's axial rotation between 1750 and 1850, and assuming that the observed inequalities in the moon's mean motion are to be accounted for by actual inequalities in the earth's rotation, then our measurements of time would be in error by amounts ranging from 17 seconds in one direction to 17 seconds in the other direction, between 1723 and 1881. Inequalities of such an amount could not fail to be indicated by the observations of the transits of Mercury. If we are required to choose between a uniform axial rotation and one varying sufficiently to account for the above inequality in the moon's mean motion, the observations of the transits make the former by far the most probable. But the transits of Mercury do show a remarkable inequality of the required kind but only one-

third its amount. If it could be supposed possible that the moon's mean motion and the earth's axial rotation varied together, the observations of the moon and of Mercury's transits would be together satisfied. But in any case Professor Newcomb concludes that inequalities in the moon's mean motion not accounted for by the theory of gravitation really exist, and exist in such a way that the mean motion of the moon between 1800 and 1875 was really less than it was between 1720 and 1800.

The discordance between the observed and the theoretical motions of the perihelion of Mercury, first pointed out by Leverrier, is also the subject of special discussion by Professor Newcomb. He concludes that this really exists, and is indeed larger than Leverrier supposed. The observed centennial motion of the perihelion of Mercury is greater by 43 seconds than the theoretical motion computed from the best attainable values of the masses of the planets. In speculating upon the possible causes of this excess of motion, Professor Newcomb says, "The most simple hypothesis is the well-known one of Leverrier, which presupposes the existence of a planet or group of planets between Mercury and the sun. That any such body or bodies of sufficient mass to produce the motion in question can really exist seems to be out of the question, for a number of reasons.

"In the first place, on any probable hypothesis of the relation of mass to reflecting power, it is impossible that a planet or group of planets of sufficient mass to produce the observed motion of the perihelion of Mercury could exist without being very conspicuous objects during total eclipses of the sun, if at no other time. We cannot, indeed, assign an exact value to the mass unless we know the mean distance. But the less we suppose the mean distance, and therefore the greater we suppose the liability that the planet should be lost in the sun's rays, the greater the mass required and the more brilliant the planet or planets would shine during a total eclipse. In fact, the more distant from the sun the required planet, the less readily it would be detected during an eclipse; but, on the other hand, it would be more readily detected at other times. In a paper published in Gould's Astronomical Journal, volume vi, the writer showed that if a group of sufficient magnitude existed, the transits over the sun would be too frequent to escape detection.

"In the next place, no such group could exist and produce the observed effect without also disturbing the secular motions of the node of Mercury and Venus. It was shown in the paper just referred to that, supposing the group to lie in the ecliptic, the excess of motion of the node would be as great as that of the perihelion. But observations do not indicate any such excess. If, therefore, the group exists its plane must be very nearly coincident with the orbit of Mercury. But here we meet with two difficulties:

"If the mean plane of the group were at any epoch coincident with that of Mercury, it could not remain so permanently, but the planes of the different orbits would, in time, group themselves

near the invariable plane of the planetary system. Again, if the coincidence had place with the orbit of Mercury it could not have place with reference to the plane of Venus, and the plane of motion of that planet would be subject to a secular variation.

"Now it is quite true, as already pointed out, that these several secular motions of the planes have not been investigated with such thoroughness that we can speak positively on this question. At the same time it appears extremely improbable that any disturbing action can exist of such magnitude as the hypothesis would imply.

"The hypotheses just considered are those of a single planet or a group of planets. It may be asked to what limit we must suppose the subdivision carried in order that the individual bodies may escape detection. The reply is that they must be so small as to be invisible either in transit across the sun or by reflected light during a total eclipse, or in the evening after sunset. Their diameters at the distance unity cannot, therefore, exceed a very small fraction of a second.

"The limit of mean diameter may be roughly placed at $\frac{1}{50}$ that of the earth, and the limit of individual volume at $\frac{1}{100000}$ that of the earth. Since the total mass must be an appreciable fraction of the mass of the earth the number of the hypothetical planets must be thousands and probably tens of thousands.

"It may be suggested that in the zodiacal light we have evidence of at least the possibility that a group of many thousand bodies, too minute to be visible to the naked eye, circulate between the earth and the sun. It would be an interesting photometrical investigation to ascertain the limit of volume of these bodies on the supposition that they are of ordinary whiteness. The extreme softness of the zodiacal light is such that the minimum number of separate bodies would have to be estimated at hundreds of thousands. The writer thinks it probable that the result would be that a collection of 100,000 bodies with a combined volume one-tenth that of the earth would glow with a much brighter light than the zodiacal light actually does. The hypothesis of the zodiacal light is subject to the same difficulties with respect to motions of the nodes as have already been pointed out with respect to the group of planets. But we have at present no way of positively disproving it.

"We may next inquire whether either a possible ellipticity of the sun or of his atmosphere, or of the matter in his interior, can produce the observed effect. The reply to this would be that the most exact measures have failed to show any ellipticity of the body of the sun at all approaching that required. Indeed, if we suppose the elliptic disturbance of matter, if I may use the expression, to be within the sun, it would probably be found that the consequent deviation of the level surfaces at the photosphere from a spherical form would lead to a sensible ellipticity of the sun's disk.

"There is a field for investigation in the question what the mass of a ring round the sun must be to produce the observed effect, and what influence that mass would have upon the motion of the nodes of Mercury and Venus. This is a question which can be

more profitably discussed when the character of the phenomena is more accurately ascertained. But, as the question now stands, all hypotheses that the observed phenomenon is produced by the attraction of unknown matter in the neighborhood of the sun or Mercury must be dismissed as at least highly improbable.

"We may next inquire whether any deviation from or modification of the law of gravitation which would produce the observed effect is admissible. The most natural modification of this kind would be the addition of a term varying as the inverse third or fourth power of the distance. This hypothesis can, however, be refuted very readily. A term of the inverse third power which, at the distance of Mercury, should have a value even the millionth part of the total gravitative force of the sun would, at the distance of a foot, have a value two hundred thousand times that of the term depending on the inverse square. If higher powers than the cube were added the discrepancy would be yet more enormous. The existence of a term of such magnitude is out of the question."

"Another hypothesis which has been considered in this connection is that of Weber's electro-dynamic theory. According to this theory the gravitative force between two bodies is expressed by an equation of the form

$$\frac{m}{r^2}\left(1 - \frac{1}{h^2}\left(\frac{dr}{dt}\right)^2 + \frac{2r}{h^2}\frac{d^2r}{dt^2}\right)$$

in which the constant h, as is evident from the formula, must be a velocity. This velocity Weber has sought to determine experimentally; his value is 439,450 kilometers per second. From this datum Tisserand has computed the secular variations of the planets. (Comptes Rendus, vol. lxxv, p. 760.)

"His results are that the only element affected with a sensible inequality is the perihelion, and that the secular motions of the perihelia of Mercury and Venus would have the following values: Mercury, 6″·28; Venus, 1″·32. If h be the velocity of light, his result is, Mercury, 13″·65; Venus, 2″·86.

"But the actual motion has been found to be three times this. To produce this motion the value of h must be reduced to about 174,000 kilometers per second. Objections have been raised to Weber's whole theory on the part of physicists, to whom the discussion of its possibility must be left."

Obituary.

Henry Seybert, an early worker in American Mineralogy, died March 3d, 1883. He contributed analyses of molybdenite from Chester, Pa., chromite, tabular spar, pyroxene, colophonite, chrysoberyl of Haddam, chondrodite of N. J.; and in the latter he independently discovered fluorine. He analyzed in 1830 the Tennessee meteorite described by Bowen. His father, Adam Seybert, was, like the son, a graduate of the École des Mines of Paris, and one of the earliest original investigators in chemistry in this country. Dr. Seybert's ample fortune is said to be distributed in various endowments, chiefly of chemistry.